GROUNDWATER RISK EVALUATION EASTERN OIL LAGOON AREA

Commonwealth Oil Refining Company **Petrochemical Complex** Peñuelas, Puerto Rico 00731

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GLOSSARY OF TERMS

Absorption - The uptake of water or dissolved chemicals by a cell or an organism.

Absorption factor - The fraction of a chemical making contact with an organism that is absorbed by the organism.

Acceptable Daily Intake (ADI) - Estimate of the largest amount of chemical to which a person can be exposed on a daily basis that is not anticipated to result in adverse effects (usually expressed in mg/kg/day). (Now termed Reference Dose).

Acute exposure - A one-time or short-term exposure (usually high-level) that may or may not cause a health problem.

Additive effect - Combined effect of two or more chemicals equal to the sum of their individual effects.

Adsorption - The process by which chemicals are held on the surface of a mineral or soil particle. Compare with absorption.

Advection - Bulk movement of a fluid in response to pressure gradients within that fluid. Distinguished from convection which is bulk movement of fluid in response to fluid density gradients.

Animal studies - Investigations using animals as surrogates for humans, on the expectation that results in animals are pertinent to humans.

Anisotrophy - Having some physical property such as permeability that varies with direction.

Bioaccumulation - the successive and increasing concentration of a chemical as one moves higher up on a food chain.

Bioconcentration - The accumulation of a chemical in tissues of an organism (such as fish) to levels that are greater than the level in the medium (such as water) in which the organism resides.

Biodegradation - Decomposition of a substance into more elementary compounds by the action of microorganisms such as bacteria.

Biotransformation - Conversion of a substance into other compounds by organisms; includes biodegradation.

Cancer - A disease characterized by the rapid and uncontrolled growth of aberrant cells into benign or malignant tumors.

Carcinogen - An agent capable of inducing a cancer response.

Carcinogenic - Capable of producing or inciting cancer.

Carcinogenic Potency Factor - Synonymous with slope factor.

Carcinogens, classification of - Group A: human carcinogen (sufficient evidence from epidemiologic studies), Group B: probable human carcinogen (subgroup Bl: limited evidence from epidemiologic studies; subgroup B2: sufficient evidence from animal studies and inadequate evidence or no data from epidemiologic studies), Group C: possible human carcinogen (limited evidence from animal studies and no data from epidemiologic studies) (EPA 1989).

Chronic - Occurring over a long period of time, either continuously or intermittently; used to describe ongoing exposures and effects that develop only after a long exposure.

Chronic Daily Intake (CDI) - Estimate of the amount of chemical taken into the body per unit body weight per unit time and is specific for each exposure pathway.

Chronic effect - A biological change produced by an alteration in the environment and persisting over a major portion of a lifetime.

Chronic exposure - Repeated or prolonged exposures (usually at low concentrations) to an environmental alteration that may or may not cause a health problem.

Cumulative exposure - The summation of exposures of an organism to a chemical over a period of time.

Degradation - Chemical or biological breakdown of a complex compound into simpler compounds.

Dermal - Pertaining to the skin.

Dermal exposure - Contact between a chemical and the skin.

Diffusion - The movement of a dissolved chemical species (solute) under the influence of its kinetic activity, in the direction of its concentration gradient.

Dispersion - The spreading of a solute from its mean flow path by the process of mechanical mixing in the aquifer matrix.

Dose - The actual quantity of a chemical to which an organism is exposed.

Dose-response curve - A graphical presentation of the relationship between degree of exposure to a chemical (dose) and observed biological effect (response).

Endpoint - A biological effect used as an index of the effect of a chemical on an organism.

Epidemiologic study - Study of human populations to identify causes of disease. Such studies often compare the health status of a group of persons who have been exposed to a suspect agent with that of a comparable non-exposed group.

Estimated exposure dose - The estimated or calculated dose to which humans are likely to be exposed.

Exposure - Contact with a chemical or physical agent.

Exposure assessment - The determination or estimation (qualitative or quantitative) of the magnitude, frequency, duration, route, and extent (number of people) of exposure to a chemical.

Exposure coefficient - Term which combines information on the frequency, mode, and magnitude of contact with contaminated medium to yield a quantitative value of the amount of contaminated medium contacted per day.

Exposure Pathway - A description for the unique mechanism by which a population or an individual is exposed to chemicals originating from a site.

Extrapolation - An estimation of the numerical value of an empirical function at a point outside the range of data that established the function.

Fetotoxic - Toxic to fetuses.

Fetus - The unborn, developing young of animals or humans.

Half-life - The length of time required for the mass, concentration, or activity of a chemical or physical agent to be reduced by one-half.

Hazard evaluation - A component of risk assessment that involves gathering and evaluating data on the types of health injury or disease (e.g., cancer) that may be produced by a chemical and on the conditions of exposure under which injury or disease is produced.

Health advisory - An estimate of acceptable drinking water levels for a chemical substance based on health effects information. A health advisory is not a legally enforceable Federal standard, but serves as technical guidance to assist federal, state/commonwealth, and local officials.

Health hazard

Acute - Immediate toxic effects.

Chronic - Persistent or prolonged injury.

Delayed - Toxic effect occurring after a lapse of time.

Hematopoiesis - The production of blood and blood cells; hemopoiesis.

Hepatic - Pertaining to the liver.

High-to-low-dose extrapolation - The process of prediction of low exposure risks from the measured high exposure-high risk data.

Histology - The study of the structure of cells and tissues; usually involves microscopic examination of tissue slices.

Human equivalent dose - The human dose of an agent which is believed to induce the same magnitude of toxic effect that the known animal dose has induced.

Human exposure evaluation - A component of risk assessment that involves describing the nature and size of the population exposed to a substance and the magnitude and duration of their exposure. The evaluation could concern past exposures, current exposures, or anticipated exposures.

Human health risk - The likelihood (or probability) that a given exposure or series of exposures may have or will damage the health of individuals experiencing the exposures.

Hydrolysis - Double decomposition reaction involving the splitting of water into its ions and the formation of a weak acid and/or a weak base.

Integrated exposure assessment - A summation over time, in all media, of the magnitude of exposure to a toxic chemical.

Latency - Time from the first exposure to a chemical until the appearance of a toxic effect.

Lifetime exposure - Total amount of exposure to a substance that a human would receive in a lifetime (usually assumed to be 70 years).

Linearized multistage procedure - A sequence of steps in which a) the multistage model is fitted to the tumor incidence data, b) the maximum linear term consistent with the data is calculated, c) the lowdose slope of the dose-response function is equated to the coefficient of the maximum linear term, and d) the resulting slope is then equated to the upper bound of potency.

Lowest Observed Adverse Effect Level (LOAEL) - The lowest dose in an experimental study at which a statistically or biologically significant adverse effect was observed.

Malignant - Tending to become progressively worse and to result in death. Having the properties of anaplasia, invasion, and metastasis.

Metastatic - Pertaining to the transfer of disease from one organ or part to another not directly connected with it.

Modeling - Use of mathematical equations to simulate and predict past or future events and processes.

Mutagen - An agent that causes a permanent genetic change in a cell other than that which occurs during normal genetic recombination.

Mutagenicity - The capacity of a chemical or physical agent to cause permanent alteration of the genetic material within living cells.

Neoplasm - An abnormal growth or tissue, as a tumor.

Neurotoxicity - Exerting a destructive or poisonous effect on nerve tissue.

No Observed Adverse Effect Level (NOAEL) - The highest experimental dose at which there was no statistically significant change in a toxicologically significant endpoint.

No observed effect level (NOEL) - The highest experimental dose at which there was no statistically significant change in any monitored endpoint.

Pharmacokinetics - The dynamic behavior of chemicals inside biological systems; it includes the processes of uptake, distribution, metabolism, and excretion.

Population at risk - A population subgroup that is more likely to be exposed to a chemical, or is more sensitive to a chemical, than is the general population.

Potency factor - An estimated upper 95% confidence limit of the carcinogenic potency of a chemical. Equivalent to ql* when it is based on animal study data evaluated by the multi-stage model. Units are expressed as (mg/kg/day)⁻¹.

Potency slope - Synonymous with slope factor.

Potentiation - The effect of one chemical to increase the effect of another chemical.

ql* - The upper-bound slope parameter for carcinogens as determined by the multistage procedure. Units expressed as (mg/kg/day)⁻¹.

Reference dose (RfD) - An estimate (with uncertainty spanning perhaps an order of magnitude) of the daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effect during a lifetime. The RfD is expressed in units of mg/kg/day. RfDc refers to chronic exposure and RfDs refers to subchronic exposure.

Renal - Pertaining to the kidney.

Risk - The difference between the cancer incidence in the treated group of animals or the exposed humans and the control group of animals or the spontaneous incidence in humans.

Risk assessment - A qualitative or quantitative evaluation of the environmental and/or health risk resulting from exposure to a chemical or physical agent (pollutant); combines exposure assessment results with toxicity assessment results to estimate risk.

Risk characterization - Final component of risk assessment that involves integration of the data and analysis involved in hazard evaluation, dose-response evaluation, and human exposure

evaluation to determine the likelihood that humans will experience any of the various forms of toxicity associated with a substance.

Risk estimate - A description of the probability that organisms exposed to a specified dose of chemical will develop an adverse response (e.g., cancer).

Risk specific dose - The dose associated with a specified risk level.

Route of exposure - The avenue by which a chemical comes into contact with an organism (e.g. inhalation, ingestion, dermal contact, injection).

Safety factor - The term formerly applied to the uncertainty factor concept.

Slope factor - The slope of the upper-bound dose extrapolation model at doses approaching zero. Risk is equal to the slope factor in (mg/kg/day)~1 times the dose in mg/kg/day.

Systemic - Pertaining to or affecting the body or organism as a whole.

Systemic effects - Systemic effects are those that require absorption and distribution of the toxicant to a site distant from its entry point at which point effects are produced. Most chemicals that produce systemic toxicity do not cause a similar degree of toxicity in all organs but usually demonstrate major toxicity to one or two organs. These are referred to as the target organs of toxicity for that chemical. (Operationally, EPA does not include carcinogens in this category).

Teratogenesis - The induction of structural or functional development abnormalities by exogenous factors acting during gestation; interference with normal embryonic development.

Teratogenicity - The capacity of a physical or chemical agent to cause non-hereditary congenital malformations (birth defects) in offspring.

Toxicity assessment - Characterization of the toxicological properties and effects of a chemical, including all aspects of its absorption, metabolism, excretion and mechanism of action, with special emphasis on establishment of dose-response characteristics.

Uncertainty Factor (UF) - Factor used in operationally deriving the RfD from experimental data. UFs are intended to account for (I) the variation in sensitivity among the members of the human population, (2) the uncertainty in extrapolating animal data to the case of humans, (3) the uncertainty in extrapolating from data obtained in a study that is of less-than-lifetime exposure, and (4) the uncertainty in using LOAEL data rather than NOAEL data. Usually each of these factors are set equal to 10. Depending on the quality of the data, the overall UF may range from I to 10,000.

Unit risk - The incremental upper-bound lifetime risk estimated to result from lifetime exposure to an agent if it is in the air at a concentration of I microgram per cubic meter or in the water at a concentration of I microgram per liter.

Upper bound estimate - Estimate not likely to be lower than the true risk.

EXECUTIVE SUMMARY

DSM Environmental Services, Inc. (DSM) conducted this preliminary groundwater risk analysis, on behalf of Commonwealth Oil Refining Company, Inc. (CORCO) for the groundwater underlying the CORCO Eastern Oil Lagoon Area. The Eastern Oil Lagoon Area is located south of Highway 127 and south and east of the CORCO facility Marine Terminal & Bulk Storage Complex, Peñuelas, Puerto Rico, as depicted in Figure 2 (Site Facility Map). The Eastern Oil Lagoon Area groundwater risk analysis was prepared in response to EPA correspondence referencing the "Revised Site Assessment and Data Validation Report" dated December 9, 1994. The U.S. Environmental Protection Agency Hazardous Waste Registration Number for the CORCO Facility is EPA ID# PRD-091017228.

This Eastern Oil Lagoon Area groundwater risk analysis was prepared in accordance with guidelines established by the U.S. Environmental Protection Agency (EPA) in its guidance documents for health risk assessments (EPA, 1986a; 1989). The purpose of this preliminary, baseline groundwater risk analysis was to assess, to the extent of available validated data, potential human health risks that may result from exposure to chemicals detected in the groundwater underlying the CORCO Eastern Oil Lagoon Area in the absence of groundwater remediation.

Methodologies suggested by the U.S. EPA (EPA, 1989) were used to evaluate the potential public health risks associated with the seven chemicals of concern detected in the Eastern Oil Lagoon Area groundwater: Trichloroethylene, Bis(2-ethylhexyl) phthalate, Aluminum, Chromium, Manganese and Vanadium. Groundwater data utilized in the Eastern Oil Lagoon Area groundwater risk analysis was obtained from previous investigations performed at the site by Roy F. Weston (1993), GDC Engineering, Inc. (1994), U.S. EPA (1994), and DSM Environmental Services (1994).

To evaluate public health risks from the chemicals of concern in the Eastern Oil Lagoon Area groundwater, a no action alternative evaluated the downgradient migration of site chemicals without the implementation of groundwater remedial actions. Based on the results of this groundwater risk analysis, the following conclusions have been reached:

- The results of the exposure assessment indicated that the only reasonable route of exposure which could occur is via the transport of contaminants in groundwater to the Tallaboa Bay. If the contaminants were to actually be transported to the bay, the most likely exposure would be to someone who might fish regularly in the area. Contact with contaminants in the bay could then occur through dermal contact or the ingestion of contaminated fish or shellfish. The current and future potential receptor population of recreational fishermen was identified for evaluation of marine biota (fish) ingestion and dermal exposure pathways.
- The non cancer Hazard Index (HI) results for the groundwater underlying the Eastern Oil Lagoon Area show that the (HI) of each individual constituent is less than one and the cumulative (HI) of all the constituents combined is also less than one. The combined HI of 0.132 indicates quite strongly that, under these exposure assumptions, the concentrations of chemicals found in groundwater in the Eastern Oil Lagoon Area are unlikely to cause any current or future adverse non-cancer toxic effects.
- The cancer risk results for the groundwater underlying the Eastern Oil Lagoon Area show that the concentration of Trichloroethylene and Bis(2-ethylhexyl) phthalate which would reach the bay results in a calculated risk of 1.94 x 10⁻⁸. Attenuation and/or bioremediation processes were not considered in the risk calculations. This value is well below the range of acceptable current or future risks identified by EPA to be 1 x 10⁻⁴ to 1 x 10⁻⁶.
- Based on the results of the Eastern Oil Lagoon Area groundwater risk analysis, no excess
 cancer risks or adverse noncarcinogenic health effects result from the absence of
 groundwater remedial action at the CORCO Eastern Oil Lagoon Area. Remedial action for
 the groundwater at the Eastern Oil Lagoon Area is not recommended.

1.0 INTRODUCTION

DSM Environmental Services, Inc. (DSM), on behalf of Commonwealth Oil Refining Company, Inc. (CORCO), has prepared this preliminary baseline groundwater risk analysis in response to the December 9, 1994 EPA correspondence referencing the "Revised Site Assessment and Data Validation Report". The intent of this preliminary, baseline groundwater risk analysis is to assess, to the extent of available validated data, potential human health risks that may result from exposure to chemicals detected in the groundwater underlying the Eastern Oil Lagoon Area to the east of the CORCO facility, Peñuelas, Puerto Rico. The Eastern Oil Lagoon Area is located south of Highway 127 and south and east of the CORCO Facility as depicted in Figure 2 (Site Facility Map). The Eastern Oil Lagoon Area is a regulated unit pending closure as per the 1990 Settlement Agreement with EPA. A hazardous waste closure plan for the Eastern Oil Lagoon Area was prepared and submitted to EPA on February 9, 1995 by DSM Environmental Services, Inc. (DSM).

This preliminary baseline groundwater risk analysis discusses potential human health risks associated with chemicals detected in groundwater beneath the site of the Eastern Oil Lagoon Area. This preliminary analysis is based in part on data contained in the Site Assessment implemented by Roy F. Weston(1993) and GDC Engineering, Inc.(1994), the Phase I: Subsurface Oil Investigation by DSM Environmental Services, Inc.(1994), and the Site Assessment Addendum Report by DSM Environmental Services, Inc.(1994). The Site Assessment, Phase I Subsurface Oil Investigation and the Site Assessment Addendum were performed in compliance with the 1990 EPA Settlement Agreement.

This preliminary groundwater risk analysis was conducted in accordance with guidelines established by the U.S. Environmental Protection Agency (EPA) for human health evaluations. The preliminary groundwater risk analysis summarizes the analytical information for the chemicals at the Eastern Oil Lagoon Area, and evaluates the environmental fate and toxicological properties of these chemicals. On the basis of this information, potential exposure routes and the receptor populations are identified, and potential current and future human health risks are quantitatively characterized.

1.1 Methodology

This groundwater risk evaluation was conducted in accordance with the guidelines established in the Risk Assessment Guidance for Superfund, Volume I - Human Health Evaluation Manual (EPA/540/1-89/002 Dec. 1989) under the comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) amended in 1986 by the Superfund Amendments and Reauthorization Act (SARA) (EPA, 1980a). The sections of the preliminary baseline groundwater risk analysis correspond to steps in the public health evaluation process:

• Section 2.0: <u>Chemicals of Concern.</u>

This section reviews analytical data used to select the chemicals to be evaluated in this preliminary baseline groundwater risk analysis. Chemicals detected in previous groundwater investigations provide the basis for this assessment.

Section 3.0: <u>Exposure Assessment</u>.

Chemical release mechanisms, transport media, and routes of exposure to sitespecific chemicals are identified.

Section 4.0: Applicable or Relevant and Appropriate Requirements.

The federal and commonwealth criteria that may be used as applicable or relevant and appropriate requirements (ARARs) are discussed.

Section 5.0: <u>Toxicity Assessment</u>.

The toxicological properties of the site chemicals and potential risks to public health resulting from chemical exposures are reviewed.

Sections 6.0: Risk Characterization.

For chemicals identified in Section 2.0, assumed chemical exposures for the primary exposure pathways are quantified and evaluated relative to appropriate toxicological criteria.

Section 7.0: Sources of Uncertainty and Error.

The potential uncertainties in the risk assessment process specific to this preliminary baseline groundwater risk analysis are discussed.

Section 8.0: <u>Summary and Conclusions</u>.

This section summarizes the results of this preliminary baseline groundwater risk analysis.

1.2 Site Description

The site associated with the preliminary baseline groundwater risk analysis is the CORCO Eastern Oil Lagoon Area southeast of the Commonwealth Oil Refining Company (CORCO), Peñuelas facility. (see **Figure 2**, Site Facility Map).

The characteristics of the site, such as local land use, local populations, history, climate, topography, regional geohydrology, lithology, depth to groundwater, and groundwater flow direction are presented. Site characterization data provides the basis for substantive assessment of exposure pathways. Site characterization data is based on information generated during the Site Assessment implemented by Roy F. Weston(1993) and GDC Engineering, Inc.(1993), the Phase I: Subsurface Oil Investigation by DSM Environmental Services, Inc.(1994), and the Site Assessment Addendum Report by DSM Environmental Services, Inc.(1994).

1.2.1 Location

Puerto Rico is the most easterly and smallest of the four major islands that form the Greater Antilles. The other three land masses within the Greater Antilles island cluster include Cuba, Jamaica, and Hispaniola. Puerto Rico is surrounded by the Atlantic Ocean to the north and the Caribbean Sea to the south. The Commonwealth Oil Refining Company is located in the south-central coast of Puerto Rico (see Figure 1 - CORCO Facility Vicinity Location Map). The south central coast is the most arid region of the Island. The hills and ridges are typically steep, with low-lying river valleys running southward from the Cordillera Central Mountains to the Caribbean Sea. Development is typically restricted to the coastal alluvial fans, coastal plains, plateaus, and inland river valleys.

The Eastern Oil Lagoon Area is located approximately one (1) mile southeast of the CORCO facility and approximately 1800 feet north of Tallaboa Bay. (see **Figure 2** - Site Facility Map).

1.2.2 Facility History

Prior to the early 1950's, agriculture was the principal land use of the property. The CORCO Facility was constructed in 1953 and operated as an independent petroleum refiner and petrochemical manufacturer in the Commonwealth of Puerto Rico. The CORCO Facility historically operated as a petroleum refining and petrochemical manufacturing plant. Petrochemical operations were suspended in November 1981 and refining operations ceased in March 1982. CORCO continues to operate part of its facilities as a products storage facility and terminal. Currently, CORCO is leasing tankage to other companies for product storage.

During the period that CORCO was operating as a refinery, the Eastern Oil Lagoon Area was used to receive API separator sludge and wastewater lagoon sludge on an annual basis. Because of the down-sizing of the CORCO operation and the regulatory shift in the definition of hazardous waste, this lagoon is pending closure under a 1990 EPA Settlement Agreement.

1.2.3 Land Use

The active CORCO Facility property consists of a hydrocarbon products storage facility and terminal which occupy approximately three hundred and fifty acres of land straddling the boundary between Municipio de Guayanilla to the west and Municipio de Peñuelas to the east. The facility has a topographic relief of approximately 280 feet. One-quarter of the facility is situated in the Lower Tallaboa Valley, which has an elevation range of 0 to 26 feet above mean sea level. Three quarters of the facility is situated on the southeastern edge of the upland ridge that separates the Guayanilla and Tallaboa River Valleys. The Eastern Oil Lagoon Area is situated outside the property boundary of the CORCO facility in the lower Tallaboa Valley which has an elevation range of 10 to 20 feet above mean sea level.

1.2.3.1 Current Land Uses

The land adjacent to the Eastern Oil Lagoon Area is mainly used for industrial purposes. The industrial activities within one-half mile radius of the Eastern Oil Lagoon Area are Caribe Isoprene to the north, Olefin Plant to the east, Union Carbide to the west, and a sulfuric acid plant and Dock No. 3 (Tallaboa Bay Dock) to the south (see **Figure 2**, Site Facility Map). Approximately half a mile to the east of the lagoon, there is a small residential community which is part of the Peñuelas municipality.

Among the industrial users, Caribe Isoprene, Olefin Plant, and Union Carbide have ceased operation. The Sulfuric acid plant and Dock No. 3 are still in operation.

1.2.3.2 Future Land Uses

The future land use in the area will continue to be industrial except the small residential community to the east as mentioned above ("La Junta De Plantificación De Puerto Rico", Mapa De Zonification De Peñuelas, map page #14, #5, and #20; October 29, 1972).

1.2.4 Geology

The CORCO Facility is located in the Tallaboa-Guayanilla-Guanica subarea of the south coast region of Puerto Rico (USGS, 1987). The three formations in the Tallaboa-Guayanilla-Guanica subarea are Quaternary Alluvium, and the Tertiary Limestones which are made up of the Ponce Limestone and Juana Diaz Limestone. Thick deposits of unconsolidated Quaternary Alluvial of boulders, gravel, sands, silts and clays underlie large portions of the Tallaboa Valley. These alternating alluvial sequences grade southward towards the Caribbean Sea to finer-grained deposits of lacustrine origin. The Quaternary lacustrine deposit composition is generally fine-grained sequences of sand, silts, clays and peat. Further southward towards the Caribbean Sea, the benthoic deposits are generally thin re-worked beach deposits of quartz sand and calcite reef rubble. The Quaternary deposits thicken seaward and are underlain by the Tertiary Limestone formations. The Quaternary Alluvial Deposits are underlain by the Tertiary Ponce Limestone in the south and by the older Tertiary Juana Diaz Limestone to the north.

The Eastern Oil Lagoon Area is located within the Quaternary Alluvium approximately one mile south of the edge of the Ponce Limestone deposit.

1.2.4.1 Quaternary Alluvial Lithology

The site lithology at the Eastern Oil Lagoon Area, as determined by previous subsurface investigations conducted at the CORCO facility, is the Quaternary Alluvial Deposits. Previous investigations in these two formations were conducted by Versar, Inc. (1986), Roy F. Weston, Inc.

(1989), GDC Engineering, Inc. (1994) and DSM Environmental Services, Inc. (1994). The geology at the Eastern Oil Lagoon Area has been determined to be the Quaternary Alluvial Deposits. The Quaternary Alluvial Deposits formation will be the lithographic unit of interest in the performance of the preliminary baseline groundwater risk analysis.

The Quaternary Alluvial Deposits are located in the low lying regions, at the CORCO Facility, south of Route 127. The road, Route 127, bisects the CORCO Facility on an east to west bearing. The roadway is built on/at the interface between the Ponce Limestone and Alluvial Deposits. Route 127 is built on the Alluvial flats and follows the contour of the Ponce Limestone hill-sides. The road base has been raised above the surrounding land surface approximately one foot. The road is the main route for heavy equipment and traffic in and through the Petrochemical Complex.

The Site Assessment (GDC, 1994) advanced eight (8) monitoring well soil borings in the alluvial to a maximum depth of thirty five (35) feet below-land-surface (ft. bls). The Phase I: Subsurface Oil Investigation (DSM, 1994) advanced an additional eight (8) piezometer soil borings in the alluvial deposits to a maximum depth of thirty (30) feet below-land-surface. The land surface elevation range, for the soil borings, ranged from 4.69 to 15.11 feet above mean sea level (ft. msl).

The four monitoring well soil borings EL-1 to EL-4, were advanced by GDC. The lithology of the native soils encountered in boring EL-1, completed to a depth of 24.2 feet, consists of a thin veneer of humus, silty clays, clayey silts and clayey very fine sand overlaying unconsolidated sands and fine and coarse gravely sands. The lithology of the soils encountered in boring EL-2, completed to a depth of 28.5 feet, consists of twelve feet of fill (tan calcareous clay with calcareous nodules), clays, silty clays, and sandy

clays overlaying unconsolidated sands. Field screening of soils with the PID did not detect any organic vapors within these borings located upgradient and downgradient of the eastern lagoon. Initial groundwater levels ranged between 7.5 and 20 feet below ground surface elevation at EL-1 and EL-2, respectively.

The alluvial deposits show a range of energy during the depositional environment. The textural maturity of the facies falls within the immature, sub-mature to mature ranges. The depositional environments in these energy ranges are flood plain, lagoon/swamp. river channel, and beach and bar environs. The facies also exhibit textural inversions that indicate multiple source material or reworked older sediments into primary deposits.

The depositional environment, encountered during the investigation of the Alluvial Deposits, is reflected by the textural maturity and textural inversions of the facies composition. The older facies, the third depositional zone, exhibit a beach-bar composition. The second depositional zone shows a range of maturity and textural inversions that is indicative of low to moderate energy environs. The winnowing and sorting of the second zone facies exhibits deposition features of lagoon/swamp and river/splay deposits. These findings are consistent with the US Geological Survey report on the water resources of the Tallaboa Valley (Grossman, et. al. 1972).

1.2.5 Hydrogeology

This regional hydrogeology discussion is based primarily on the US Geological Survey report on the water resources of the Tallaboa Valley by Grossman et. al. (1972). Unconsolidated deposits of sand and gravel, in the central portion of the valley, are by far the most productive water-bearing material in the Tallaboa Valley region. The Ponce Limestone may serve as a supplemental source of water to wells tapping the overlying sand and gravel. Wells in the Quaternary Alluvial have the highest specific capacity and yield. The maximum yield is reported at 1,200 gpm

(USGS, 1972). The average yield of forty nine (49) wells tapping the sand and gravel aquifer is about 260 gallons per minute (gpm), with individual wells yielding upwards to 1,650 gpm. In spite of the low yield and a wide range in chemical quality of groundwater, the Ponce Limestone is the only productive bedrock in the area and is second only to the unconsolidated sand and gravel as a source of water. The average yield of four wells tapping this rock is 30 gpm, the maximum yield being 100 gpm. Salt water intrusion in the alluvium is common near the sea and inland in heavily pumped supply wells. The Beach and dune deposits commonly contain salt water.

Saltwater intrusion from the sea was reported as early as 1961 to be affecting wells south of Route 127. Further studies by the USGS in 1966 showed many wells in this area reporting increased chloride concentrations, the predominant anion of sea water (USGS, 1972). The fresh water supplies for potable and industrial use are obtained from well fields owned and operated by the industries or by the Puerto Rico Aqueduct Authority. Public potable water delivered by the Puerto Rico Aqueduct Authority supplied from the Grazas Dam Resevoir, the Yauco Reservoir, and a well field. The well field is located north of Highway 2, in the north Tallaboa Valley, and is completed in the alluvial gravel and sand aquifer. Saltwater intrusion, has shut down most potable water wells in the Tallaboa Valley Region south of Route 127 (See Figure 3 Instrusion of Salt Water in the Tallaboa Valley; USGS Survey; Water - Resources Bulletin 7; Water Resources of the Tallaboa Valley, Puerto Rico 1972).

Based on this discussion, it can be said that the groundwater in the Eastern Oil Lagoon Area is non-potable brackish water. No potable water wells exist in the area of the eastern lagoon or down gradient of the Eastern Oil Lagoon Area. The poor quality of the water in the area of precludes the future installation of potable, agricultural or industrial water wells.

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1.2.6 Groundwater

This preliminary baseline groundwater risk analysis is primarily concerned with identifying the subsurface migration pathways at the Eastern Oil Lagoon Area of the CORCO Facility. The hydraulic characteristics of concern in the Eastern Oil Lagoon Area include groundwater flow direction and hydraulic gradient. Field data collection methods were conducted as recommended in the RCRA: Groundwater Monitoring Technical Enforcement Guidance Document (TEGD, USEPA, 1986)

Groundwater level measurements were collected by DSM Environmental Services, Inc. from monitor wells and piezometers to establish the hydraulic gradient at the Eastern Oil Lagoon Area. Groundwater levels were recorded for monitor wells EL-1, EL-2, EL-3, and EL-4. **Table 1** presents the groundwater level data obtained on September 27, 1994 and October 5, 1994. All measurements were recorded to the nearest hundredth (0.01) of a foot and referenced to a marked location on the well casing. The static water level measurements were collected by an electric line probe (E-line). This instrument was the only non-dedicated equipment to enter the wells.

1.2.6.1 Groundwater Flow Direction

The static groundwater level measurements were collected by DSM Environmental Services, Inc., on September 27, 1994 and October 5, 1994, from monitoring wells near the Eastern Oil Lagoon Area. The measurements were collected within a two and one half (2.5) hour period. The collected level measurements are tabulated in **Table 1**.

The level measurements were reduced to feet mean sea level (ft.msl) to construct a potentiometric surface map at the CORCO Facility. The corrected groundwater level measurements were then plotted as **Figure 5**: Potentiometric Measurement Map (09/27/94) and **Figure 6**: Potentiometric Measurement Map (10/05/94). The groundwater flow is assumed to be steady-state, laminar and validates Darcy's Law. These assumptions were

used to generate both the September 27, 1994 and October 5, 1994 potentiometric surfaces at the Facility near the Eastern Oil Lagoon Area.

The Eastern Oil Lagoon Area potentiometric surfaces range from a level of 0-0.82 to 5.22 ft. msl. The standard potentiometric level was between zero and one ft. above msl. The September 27, 1994 and October 5, 1994 potentiometric surfaces indicates a groundwater flow direction southwest into the Tallaboa Bay. The groundwater flow direction indicates the migration pathway, from a point source, is southwest towards Tallaboa Bay.

1.2.6.2 Groundwater Gradient

The hydraulic gradient has been calculated for the southwest groundwater flow direction towards Tallaboa Bay. The hydraulic gradient is defined as the change in static head per unit distance in a given direction. The hydraulic gradient defines the direction of flow. The hydraulic gradient was calculated from wells with intermediate water levels (Heath, USGS Paper 2220, 1989).

The September 27, 1994, groundwater gradient is calculated from the static level measurements of monitoring wells EL-1, EL-2 and EL-3. The upgradient well, for the southwest groundwater flow direction, is EL-1 and the down-gradient well is EL-2 and EL-3. The level measurements for EL-1, EL-2, and EL-3 are 5.22, 1.02, and 0.89 ft. msl, respectively. The distance between EL-1 and EL-2 is approximately 600 ft., and the distance between EL-1 and EL-3 is approximately 700 ft. The change in head between EL-1 and EL-2 is 4.20 ft., and between EL-1 and EL-3 is 4.33 ft. The calculated hydraulic gradient from EL-1 to EL-2 is 7.0 x 10⁻³ ft/ft, and from EL-1 to EL-3 is 6.18 x 10⁻³ ft/ft. The average calculated hydraulic gradient, for the southwest groundwater flow direction, is 6.59 x 10⁻³ ft/ft.

The October 5, 1994, groundwater gradient is calculated from the static level measurements of monitoring well EL-1, and EL-2 and EL-3. The upgradient well, for the southwest groundwater flow direction, is EL-1 and the down-gradient wells are EL-2 and EL-3. The level measurements were 5.41, 1.48, and 1.51 ft. msl, respectively. The distance between EL-1 and EL-2 is 600 ft., and the distance between EL-1 and EL-3 is 700 ft. The change in head between EL-1 and EL-2 is 3.96 ft., and between EL-1 and EL-3 is 3.93 ft. The calculated hydraulic gradient from EL-1 to EL-2 is 6.6 x 10⁻³ ft/ft, and from EL-1 to EL-3 is 5.61 x 10⁻³ ft/ft. The average calculated hydraulic gradient, for the west southwest groundwater flow direction, is 6.11 x 10⁻³ ft/ft.

The average calculated hydraulic gradients of 6.59 x 10⁻³ ft/ft and 6.11 x 10⁻³ ft/ft confirm a relatively flat gradient in the Eastern Oil Lagoon Area with a southwest groundwater flow direction. The gradient pathway indicates a groundwater surface that is flat and has a flow characteristic of moving slowly towards Tallaboa Bay.

2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The groundwater data utilized in this preliminary baseline groundwater risk analysis was obtained from previous investigations performed at the site by Roy F. Weston (1993), GDC Engineering, Inc. (1994), US EPA (1994), and DSM Environmental Services (1994). The Appendix IX constituents detected in Groundwater at the Eastern Oil Lagoon Area by GDC and EPA are presented in Table 1 (See Tables Section). By direction of EPA, the only analytical data utilized for this risk evaluation was the EPA Split Samples identified as EPA EL-1 through EPA EL-4 in Table 1 (See Tables Section). The frequency, assumed detection limit and range of concentration of detected chemicals are summarized in Table 2-1.

Table 2-1: Frequency, Assumed Detection Limit, & Range Of Detected Concentration Of
Appendix IX Constituents Detected In Groundwater At Eastern Oil Lagoon Area

CHEMICAL	FREQUENCY OF OF DETECTION	ASSUMED 50 DETECTED 500 LIMIT*	RANGE OF LACTOR TO THE CONCENTRATION
		(µg1)	(rg/l)
VOLATILES			
Acetone	1/4	100	130
Benzene	1/4	5	2.9
cis-1,2-Dichloroethene	1/4	NA	24
Trichloroethylene	1/4	5	14
Vinyl Chloride	1/4	10	7.4
SEMI-VOLATILES			
Di-n-octyl phthalate	1/4	10	0.9
Bis (2-ethylhexyl) phthalate	1/4	10	19
TOTAL METALS AND CO	ONVENTIONALS		
Aluminum	4/4	NA	78300 - 200500
Calcium	4/4	NA	183000 - 601000
Copper	3/4	20	376 - 511
Chromium	4/4	50	149 - 434
Iron	4/4	NA	143400 - 377800
Magnesium	4/4	NA	84000 - 174000
Manganese	4/4	NA	4190 - 7830
Mercury	3/4	0.2	0.28 - 0.34
Sodium	4/4	NA	67000 - 189000
Lead	2/4	40	13 - 39
Vanadium	3/4	200	735 - 1500
Zinc	2/4	10	1150 - 1210

^{*} Detection limits for constituents were derived from GDC report.

NA - Not Available.

Nineteen organic and inorganic chemicals were detected in groundwater samples collected from the Eastern Oil Lagoon Area. Since such a large number of chemicals were detected in the groundwater at the Eastern Oil Lagoon Area, further reduction in the number of chemicals was necessary for quantitative risk evaluation to avoid distracting from the dominant risks presented by the site. The reduction in the number of chemicals was conducted in accordance with the guidelines established in Risk Assessment Guidance For Superfund by US EPA. Thirteen of these chemicals were eliminated from further quantitative risk evaluation. The rationale for the procedure to reduce the number of chemicals of potential concern is discussed below:

- 2.1 Analytical Certainty (eg. PQL, Qualifiers, Detection Frequency etc.)
- 2.2 Comparison with the Background Levels
- 2.3 Concentration-Toxicity Screen
- 2.4 Selection Of Chemicals

2.1 Analytical Certainty

Although Contract Laboratory Program (CLP) was developed to ensure that consistent QA/QC methods are used when analyzing hazardous waste samples, it does not ensure that all analytical results are consistently of sufficient quality and reliability for use in quantitative risk assessment. Hence, the face value of the analytical results can not be accepted for quantitative risk assessment. Instead, the limitations and uncertainties associated with the data -- according to the steps outlined below -- must be evaluated to insure that only appropriate and reliable data are carried through the process of quantitative risk assessment.

• Evaluate the Practical Quantitation Limit (PQL) for all of the chemicals assessed in groundwater. The PQL indicates the levels at which measurements can be

"trusted". The qualifiers attached to certain data often pertain to QA/QC problems and generally indicate questions concerning chemical identity, chemical concentration, or both. All the qualifiers must be evaluated for their identity or meaning before the chemical can be used in quantitative risk assessment.

- Evaluate the detection frequency for all chemicals assessed in groundwater.
 Chemicals that are infrequently detected can be artifacts in the data due to sampling,
 analytical or other problems. A pre-approved detection frequency (eg. five percent)
 may be used to screen some chemicals.
- Benzene, Vinyl Chloride, and Di-n-octyl phthalate were detected at non-quantifiable levels. The analytical data for these constituents are also flagged with J qualifier which represent the estimated concentration value. Therefore, these constituents were not evaluated in the quantitative risk assessment.

2.2 Background Levels

Typically, background samples are collected at or near the contaminated site in the direction upgradient to the groundwater flow. The constituents detected in background samples provide information on naturally occurring chemicals that have not been influenced by humans. The comparison with naturally occurring levels is applicable only to inorganic chemicals. The majority of organic chemicals found at contaminated sites are not naturally occurring even though they may be ubiquitous.

No chemicals were eliminated based on this criteria because no data was available for background levels to which the chemical concentrations could be compared. In future ongoing site-specific field work, background sample/s will be collected to more fully characterize background levels at the Eastern Oil Lagoon Area groundwater.

2.3 Concentration-Toxicity Screen

The objective of the Concentration-Toxicity Screen (C-T Screen) procedure is to identify

the chemicals in groundwater that, based on concentration and toxicity, are most likely to

contribute significantly to risks calculated for exposure scenarios involving groundwater, so

that the risk assessment is focused on the "most significant" chemicals. The results of C-T

Screen procedure are detailed in Table 2-2. The steps involved in this procedure are

described below.

2.3.1 Individual Chemical Score Calculation

Two of the most important factors, when determining the potential effect of a

chemical in risk assessment, are its measured concentrations and its toxicity.

Therefore, in this screening procedure, each chemical in groundwater, that has

passed the analytical certainty screen for data usability, is scored according to its

concentration and toxicity to obtain a risk factor. The calculation to determine the

individual chemical score is presented below.

Ri = (Ci)(Ti)

Where:

Ri = Risk factor for chemical i

Ci = Concentration of chemical i

Ti = Toxicity value for chemical i (either slope factor or 1/RfD)

A separate risk factor is calculated for carcinogenic and non-carcinogenic effects.

2.3.2 Total Chemical Score Calculation

Chemical-specific risk factors are then summed up to obtain the total risk factor for

all chemicals of potential concern in groundwater at the Eastern Oil Lagoon Area.

The relationship for deriving the total chemical score is illustrated below.

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$$R_{Total} = R1 + R2 + R3 + \dots + Ri$$

Where:

 R_{Total} = Total risk factor in groundwater

R1 + . . . + Ri = Risk factors for chemicals 1 through i

A separate R_{Total} is calculated for carcinogenic and non-carcinogenic effects.

2.3.3 Chemical Ratio Calculation

The chemical ratio is then calculated by dividing the risk factor for each chemical (Ri) by the total risk factor (R_{Total}) . This chemical ratio approximates the relative risk for each chemical in groundwater.

2.3.4 Elimination Of Chemicals

The chemical ratio (Ri/R_{Total}) for each chemical is carefully reviewed and compared with the specified limit to establish inclusion or elimination from the quantitative risk assessment. The specified limits are conservatively set at 0.01 for carcinogens and non-carcinogens. A chemical that contributes less than the specified fraction of the total risk factor is not considered further for quantitative risk assessment. Chemicals exceeding the limit are considered likely to contribute significantly to risks, as calculated in the subsequent stages of risk assessment.

The Concentration - Toxicity Screening procedure eliminated from further quantitative risk assessment ten (10) chemicals because the chemical ratio (Ri/R_{Total}) for these chemicals did not exceed the specified limit of 0.01. The chemicals eliminated by C-T screen include Acetone, cis-1,2-Dichloroethene, Calcium, Copper, Iron, Magnesium, Mercury, Sodium, Lead and Zinc and are shaded in Table 2-2.

Table 2-2: Concentration - Toxicity Screening

Constituent	Maximum Conc. (mg/L)	SFo (mg/kg-d)-1	RfDo (mg/kg-d)	Carcinogen Chemical Score (Ri) (Conc. x SFo)	Carcinogen Chemical Ratio (Ri/Rtotal)	Noncancer Chemical Score (Ri) (Conc. x SFo)	Noncancer Chemical Ratio (Ri/Rtotal)
Acetone	0.13	NA »	1.00E-00	0.00E+01	0.00E+01	1.30E+01	6.21E-03
cis-1,2-Dichloroethene	0.024	, NA 🥳	1.00E-01	0.00E+011	: .0:00E+01	2.40E+01 a	1.15E-02,
Trichloroethylene	0.014	1.10E-01	6.00E-02	1.54E-03	3.67E-00	2.33E+01	1.11E-02
Bis(2-ethylhexyl) phthalate	0.019	1.40E-01	2.00E-01	2.66E-03	6.33E-00	9.50E-00	4.54E-03
Aluminum	200.5	NA	1.00E+01	0.00E+01	0.00E+01	2.01E+03	9.58E-01
Calcium.	601	NA	NA	0.00E+01	10.00E+01	0.00E+01*	0.00E+01
Соррег	0.511	NA .	3.71E-01	, 0.00E+01	0.00E+01	1.38E+02 🛪	6.58E-02
Chromium	0.434	NA	5.00E-02	0.00E+01	0.00E+01	8.68E+02	4.15E-01
lron , , , , , , , , , , , , , , , , , , ,	377.8	NA	NA .	0.00E+01	0.00E+01 *	0.00E+01;*	* 0.00E+01
Magnesium	174 1604 174	NA TITE	"NA"	0.00E+01 ₀	*0.00E+01	*0.00E+01	0.00E+01
Manganese	7.83	NA	5.00E-02	0.00E+01	0.00E+01	1.57E+04	7.48E-00
Mercury	0.00034	NA	3.00E-03	0.00E+01	0.00E#01	-1.13E+01	* 5,41E-03
Sodium	189`` * ີ``	NA NA	' NA'	0.00E+01₩	40000E1014k	≥ 0.60E164	0.00E+01
Lead	0.039	. NA	ale NA	0.00E+01	0.00E+01	0.00E+01	: 0,00E+01
Vanadium	1.5	NA	7.00E-02	0.00E+01	0.00E+01	2.14E+03	1.02E-00
Zinc	1.21	NA 🐬	3.00E-00	0.00E+01	∂0.00E ≱ 01	4103E401	193E-02
		#	Rtotal	4.20E-03	1.00E+01	2.09E+04	1.00E+01

2.4 Selection Of Chemicals:

The selected chemicals of potential concern in groundwater at the Eastern Oil Lagoon Area are listed below.

Trichloroethylene

Bis (2-ethylhexyl) phthalate

Aluminum

Chromium

Manganese

Vanadium

The above listed chemicals of potential concern in the Eastern Oil Lagoon Area groundwater are further evaluated for quantitative risk assessment in the subsequent sections.

3.0 EXPOSURE ASSESSMENT

This section identifies the potential for human exposure to chemicals detected in the groundwater at the Eastern Oil Lagoon Area. This section identifies the potential receptor population, various exposure pathways, and the fate and transport considerations associated with these chemicals. An analysis of present and future potential human exposures is included.

3.1 Receptor Population

A receptor population is one that can potentially be exposed to site chemicals at a specific exposure point, which is that point at which human contact with a chemical can occur. Potential receptor populations are identified from information on the migration of site-specific chemicals, and the sensitivity of the receptors. Current and potential future receptor populations are identified in this section.

3.1.1 Human Receptors

As discussed in Section 1.2.3.1, the current land use surrounding the site is classified as industrial. The residential population nearest to the site is approximately one-half mile away and is not in the flow direction of the groundwater. The flow path of the groundwater is to the Tallaboa Bay where the usage of the water is defined by the Puerto Rico Environmental Quality Board (PREQB) as SC (Puerto Rico Water Quality Standard Regulation, Amended version, February 28, 1983. p.37). SC is defined by the PREQB as "Coastal waters for uses where the human body may come in indirect contact with the water (such as fishing, boating, etc.), as for use in propagation and maintenance of desirable species." Additionally, the land between the Eastern Oil Lagoon Area and the Tallaboa Bay is largely uninhabited with the exception of the Tallaboa dock onehalf mile due south of the area. Based on this discussion, the human receptors identified for consideration are the recreational fishing and boating population in the Tallaboa Bays.

3.2 Fate and Transport Considerations

This section details the factors considered in assessing the short-term and long-term behavior of the site-specific chemicals. Chemical, physical, and biological processes can affect the fate and transport of chemicals in groundwater, and can subsequently affect exposure to receptor populations. The major processes affecting chemical fate and transport at the Eastern Oil Lagoon Area are expected to be advection, dispersion, adsorption, and biodegradation. The extent to which each process occurs depends on the physical and chemical properties of each compound, the physical and chemical properties of the groundwater formation, and factors such as volume and velocity of the groundwater movement. The physical and chemical properties related to the relative environmental mobility and possible migration paths of the seven on-site chemicals were considered. These properties include molecular weight, specific gravity, vapor pressure, water solubility, the log octanol/water partition coefficient, the organic carbon partition coefficient, and the anaerobic decay coefficient. They are presented in Section 5.0.

These processes combine to result in a reduction of chemical concentrations in groundwater. The half-life, or T1/2, is the time required for the concentration of a specific compound to be reduced by one half, as a result of all processes that remove or degrade that chemical. Estimated half-life values, where appropriate, for each site chemical in groundwater are provided in Section 5.0. The processes important to each site chemical are summarized in the following section.

According to the US EPA Risk Assessment Guidance for Superfund Volume I Human Health Evaluation Manual (Page 6-11), fate and transport considerations identify media that are receiving or may receive site-related chemicals.

3.2.1 Site-Specific Fate and Transport Process of the Site Chemicals

At the Eastern Oil Lagoon Area, the principal source area for introduction of chemicals into the groundwater appears to have been the former Eastern Oil Lagoon. As the hydrocarbon front moved downward through the unsaturated zone,

lateral spreading of the chemicals occurred as a result of anisotropy in the transporting medium. Because soil permeability is greater horizontally than vertically due to sedimentary stratification, infiltrating chemicals will also spread laterally as they migrate downward beneath a source area.

As was discussed in Section 2 of this document, the Chemicals of Concern (COC's) for the groundwater at the Eastern Oil Lagoon Area are Trichloroethylene, Bis(2-ethylhexyl)phthalate, Aluminum, Chromium, Manganese and Vanadium. These chemicals are dissolved in the groundwater, therefore the transportation route for these chemicals is through the groundwater. Because the flow direction of the groundwater in the Eastern Oil Lagoon Area is southwestward to Tallaboa Bay, the COC's are carried in the groundwater to Tallaboa Bay and eventually into the Caribbean Sea.

3.2.1.1 Inorganics

Among these seven chemicals, the four metals to include Aluminum, Chromium, Manganese and Vanadium are not expected to be biodegraded. Although these metals may be precipitated and lose mobility in the formation, for the sake of simplicity and conservatism, no physical, chemical or biological transformation is assumed in this risk analysis.

3.2.1.2 *Organics*

For the two hydrocarbon chemicals of concern, Trichloroethylene, Bis(2-ethylhexyl)phthalate, it is expected that biodegradation will occur during the groundwater transport process. Because of the low level of contaminant concentration initially detected, no physical, chemical or biological transformation is assumed in this risk analysis

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3.3 Current and Future Use Exposure Pathway

Exposure to chemicals may occur through the following potential pathways:

- Consumption of marine fish by recreational fishermen
- Dermal contact with Tallaboa Bay waters by recreational fishermen

The relative importance of these pathways are discussed below.

3.3.1 Groundwater

The Eastern Oil Lagoon Area, to include all downgradient groundwater to Tallaboa Bay, does not currently contain any potable, agricultural, or industrial water wells. Groundwater monitoring wells represent the only potential route of human exposure. Monitoring wells were not considered to be appropriate to this risk assessment as the potential human receptors are required to sample said wells under the guidance of a site-specific Health and Safety Plan (H&SP). The H&SP identifies risk and provides for the protection of the potential human receptor. The poor ground water quality in this area precludes its current or future use as a source of potable, agricultural or industrial water. The current and future possible human receptors' exposure pathways do not include exposure to groundwater.

3.3.1.1 Inhalation

The quality of air at the Eastern Oil Lagoon Area will not be affected by emissions of vapors from undisturbed areas where chemicals are present in the groundwater. This groundwater risk evaluation does not quantify public health risks from inhalation of chemicals from the groundwater at the Eastern Oil Lagoon Area.

3.3.1.2 Ingestion of Soil or Water

Ingestion of soil from the site is not considered an appropriate or primary route of human exposure for groundwater contaminants. Ingestion of groundwater as a source of drinking water is ruled out as a primary exposure pathway for this groundwater risk evaluation due to the land use, plume pathway and high chlorine content. This groundwater risk evaluation does not quantify public health risks from the ingestion of soil or groundwater from the Eastern Oil Lagoon Area.

3.3.1.3 Dermal Contact

Dermal contact from the groundwater or the soil in the Eastern Oil Lagoon Area is not considered an appropriate or primary route of human exposure for groundwater contaminants. This groundwater risk evaluation does not quantify public health risks from the dermal contact with the groundwater at the Eastern Oil Lagoon Area.

3.3.2 Surface Water - Marine

As discussed in previous sections, the human receptors of concern are the recreational fisherman in Tallaboa Bay. The current and future potential human receptors' exposure pathways to surface waters are: 1) the dermal contact of the surface Tallaboa Bay water by the fisherman, and 2) the ingestion of the biota (fish), which are in direct contact with Tallaboa Bay water, by the recreational fisherman.

3.3.2.1 Ingestion Marine Biota

Ingestion of marine biota in contact with the surface waters of Tallaboa Bay is considered an appropriate and primary route of human exposure for groundwater contaminants. This groundwater risk evaluation does quantify public health risks from the ingestion of marine biota in direct contact with the waters of Tallaboa Bay by recreational fishermen.

3.3.2.2 Dermal Contact

Dermal contact with the surface waters of Tallaboa Bay is considered an appropriate and primary route of human exposure for groundwater contaminants. This groundwater risk evaluation does quantify public health risks from the dermal contact with the surface waters of Tallaboa Bay by recreational fishermen.

3.4 Summary of Exposure Pathway

The primary current and future pathways of exposure to human population receptors from the groundwater at the Eastern Oil Lagoon Area include the indirect dermal contact of the surface Tallaboa Bay water by the recreational fisherman, and the indirect contact through ingestion of the marine biota (fish), which are in direct contact with Tallaboa Bay water, by the recreational fisherman.

4.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

4.1 Introduction

Under the Resource Conservation and Recovery Act (RCRA, remedial actions must provide for a degree of cleanup and control of further release of hazardous substances, pollutants, and contaminants that assures protection of human health and the environment. Any hazardous substance, pollutant, or contaminant left on site must meet, upon completion of remedial actions, a level or standard of control that at least meets standards, requirements, limitations, or criteria that are "applicable or relevant and appropriate requirements" (ARARs) under the circumstances of the release. Potential chemical-specific and location-specific ARARs for the Eastern Oil Lagoon Area, are discussed below.

4.2 Definition of ARARs

ARARs are standards, requirements, limitations, or criteria that have been promulgated under federal or state/commonwealth law. "Applicable" requirements include all promulgated federal or state/commonwealth standards that "specifically address a hazardous constituent, remedial action, location or other circumstance at a RCRA site. "For a standard to be "applicable," all jurisdictional prerequisites must exist, so that the requirement would apply if the action were not undertaken pursuant to RCRA. "Relevant and appropriate" requirements are promulgated federal or state/commonwealth requirements designed to address problems similar to those encountered at the RCRA site, even though such requirements are not legally applicable.

USEPA has identified three categories of ARARs:

 Ambient or chemical-specific requirements that set health or risk-based concentration limits or ranges for particular chemicals (e.g. National Ambient Air Quality Standards),

- Performance, design, or action-specific requirements that govern particular activities
 (e.g., RCRA regulations for closure of hazardous waste storage or disposal units),
 and
- Location-specific requirements, (e.g., federal and state/commonwealth citing laws for hazardous waste facilities).

RCRA limits the scope of ARARs to those requirements that have been promulgated. In addition, promulgated state/commonwealth standards that are more stringent than federal requirements can be considered potential ARARs. EPA's *Interim Guidance on Compliance with ARARs* (EPA, 1987d) defines "promulgated requirements" as "laws imposed by state/commonwealth legislative bodies and regulations developed by state agencies that are of general applicability and are legally enforceable." General state policies that are formally promulgated and consistently applied have the same weight as more explicit numerical standards. Advisories and policy or guidance documents issued by federal or state/commonwealth agencies that are not legally binding are not treated as ARARs. However, they may still be considered in determining an appropriate protective remedy.

4.3 Alternatives to ARARs

The Resource Conservation and Recovery Act (RCRA) provides that a cleanup standard that assures protection of human health and the environment but does not achieve a level of control equivalent to an ARAR may be allowed if one of the following six conditions are met:

- 1. The remedial action is only part of the total action that will ultimately attain ARARs,
- 2. Compliance with the ARAR will result in greater risk to human health and the environment than alternative options,

- 3. Compliance is technically impracticable from an engineering perspective,
- 4. The selected remedial action will achieve the same level of cleanup through another method or approach,
- 5. A state/commonwealth has not consistently applied a state/commonwealth ARAR in similar circumstances in connection with other remedial actions within the state/commonwealth, or
- The ARAR would require too great an expenditure from the "Superfund".

If it is determined that any exception is applicable, ARARs may be waived as long as the remedial actions protect human health and the environment.

Where there are no specific ARARs for a particular chemical or situation, or where ARARs are not sufficient to protect human health and the environment, critical toxicity factors (such as Reference Doses or Carcinogenic Potency Factors) are used to ensure that a remedy is protective.

4.4 Development of ARARs

ARARs must be identified on a site-specific basis and are determined by the specific chemicals of concern identified at the site, the characteristics of the site, and the proposed remedial actions. ARARs should be identified and considered at multiple points in the remedial planning process. ARARs are identified in three steps:

• the site chemicals and the media (air, groundwater, or soil) in which they are found are identified.

- the potential or actual uses of the affected media are determined. Based on the potential uses, ARAR cleanup standards for each chemical in each medium are identified.
- possible remedial action alternatives that can attain the required degree of cleanup are evaluated. During the process of conducting the public risk assessment or health evaluation, the potential chemical-specific ARARs and location-specific ARARs are identified (or identified more comprehensively than during the scoping of the RI/FS) to help determine cleanup goals.

4.5 Site Chemicals

As discussed in Section 2.0, the chemicals of concern at the site include Trichloroethylene, Bis (2-ethylhexyl) phthalate, Aluminum, Chromium, Manganese and Vanadium. ARARs or critical toxicity factors, such as Reference Doses or Carcinogenic Potency Factors, for each of these chemicals are below with regard to the groundwater.

4.6 Media of Concern/Potential or Actual Uses of Affected Media

Air, soil and drinking water ARARs for the CORCO Eastern Oil Lagoon Area were not considered appropriate for the groundwater risk analysis. As discussed in Section 3.0, the quality of air at the facility will not be affected by emissions of vapors from undisturbed areas where chemicals are present in the groundwater; ingestion of and dermal contact with soil from the site are not considered primary routes of human exposure for groundwater contaminates; and ingestion of groundwater as a source of drinking water is ruled out as a primary exposure pathway for this groundwater risk evaluation due to the land use, plume pathway and high chloride content.

The primary media of concern is the groundwater underlying the Eastern Oil Lagoon Area.

The primary pathway of exposure is to recreational fisherman in Tallaboa Bay through

ingestion of fish and dermal contact. ARARs relative to the primary media of concern and pathways of exposure are presented below for each chemical of concern.

4.7 Chemical-Specific ARARs for the Eastern Oil Lagoon Area

4.7.1 Trichloroethylene

AMBIENT WATER QUALITY CRITERIA, Human Health (45 FR. 79318 - 11/28/80)

Fish Consumption Only -- 8.07E+1 μg/l

AMBIENT WATER QUALITY CRITERIA, Aquatic Organisms (45 FR. 79318 - 11/28/80; Quality Criteria for Water, EPA 440/5-86-001 (5/87))

Marine:

Acute LEECH -- 2.0E+3 μg/l

Chronic LEC -- none

4.7.2 Bis(2-ethylhexyl) phthalate

AMBIENT WATER QUALITY CRITERIA, Human Health (45 FR 79318 (11/28/80))

Fish Consumption Only -- $5E+4 \mu g/L$

AMBIENT WATER QUALITY CRITERIA, Aquatic Organisms (45 FR 79318 (11/28/80))

Marine:

Acute LEC -- 4.0E+2 μg/l

Chronic LEC -- 3.6E+2 µg/1

4.7.3 Aluminum

AMBIENT WATER QUALITY CRITERIA, Human Health

Fish Consumption Only -- none

AMBIENT WATER QUALITY CRITERIA, Aquatic Organisms

Marine:

No Data Available

4.7.4 Chromium

AMBIENT WATER QUALITY CRITERIA, Human Health (45 FR 79318 - 11/28/80)

Fish Consumption Only -- none

AMBIENT WATER QUALITY CRITERIA, Aquatic Organisms (50 FR 30784 - 07/28/85)

Marine:

Acute LEC -- 1.1E+3 μg/l (1-hour average)

Chronic LEC -- 5.0E+1 µg/l (4-day average)

4.7.5 Manganese

AMBIENT WATER QUALITY CRITERIA, Human Health (Quality Criteria for Water, July, 1976, PB-263943)

Fish Consumption Only -- none

AMBIENT WATER QUALITY CRITERIA, Aquatic Organisms

Marine:

No Data Available

4.7.6 Vanadium

AMBIENT WATER QUALITY CRITERIA, Human Health

Fish Consumption Only -- none

AMBIENT WATER QUALITY CRITERIA, Aquatic Organisms

Marine:

No Data Available

5.0 TOXICITY ASSESSMENT

The toxicity of each of the seven site chemicals is discussed below. Critical toxicity values (numerical values describing a chemical's toxicity) outlined in the profiles are combined with results of the exposure assessment to characterize potential health risks. EPA's verified reference doses (RfD), evaluations by EPA's Carcinogen Assessment Group, and Health Effects Assessment documents (HEAs) developed by EPA's Office of Research and Development serve as sources of critical toxicity values. RfDs and CPFs for the exposure pathways established by EPA (1989) were used to quantify potential carcinogenic and noncarcinogenic health risks.

The information summarized below is used to evaluate adverse health effects that may occur because of exposure to chemicals, and helps guide decisions regarding types of risks to be quantified in the risk characterization process.

5.1 Summary of Toxicological Effects for Trichloroethylene

5.1.1 Physical and Chemical Properties of Trichloroethylene

A summary of the physical and chemical properties of Trichloroethylene follows:

Molecular weight:	131.38 g/mole ⁴
Boiling point:	86.7 °C ^f
Solubility:	Insoluble ^f
Flash point:	89.6 °C ^f
Vapor pressure:	100 mm Hg at 31.4 °C $^{\rm g}$
Octanol/water partition coefficient (Log Kov	v): 2.42 ^e
Organic carbon partition coefficient (Koc):	2.10 ^e
Appearance:	Colorless Liquidf
Melting Point	-73 °C ^f
Upper explosive limit in air:	90 % ^f
Lower explosive limit in air:	12.5 % ^f

Specific gravity: 1.4649^f

Heat of Vaporization: 31.4 kJ/ mole^h

Half life in air: N/A

Half life in surface water: N/A

Fish bioconcentration factor (BCF): N/A

Reference Dose (RfD): 6.00E-03 (mg/kg-d)

Slope Factor (Sfo): 1.10E-02 1/(mg/kg-d)

a From: Casarett and Doull's Toxicology, 1991.

b From: The Merck Index, 1989.

c From: IRIS Electronic Media, 1995.

d From: Hawley's Condensed Chemical Dict., 1993.

e From: Dr. Ludwig Table-Properties of Contaminants..., 1990.

f From: Sax's Dangerous Properties of Industrial Materials, 1992.

g From: CRC Handbook of Chemistry and Physics, 1981.

h From: Lange's Handbook of Chemistry, 1992.

N/A = Information Not Available

5.1.2 Toxicity

Trichloroethylene is one of the most frequently found contaminants of both raw and treated drinking water in the United States. It is of concern for human health because it has been found to cause pulmonary adenocarcinomas and heptacellular carcinomas in mice, although bioassays of the compound in rats have been negative. Human data are inconclusive. However, studies have shown in two California cases that there was not a significant health risk at levels that have been detected in the environment. Other effects in experimental animals, such as changes in body weight, the liver, and the kidneys, have been observed at very high doses.^a It thought to be moderately toxic experimentally by ingestion and intraperitoneal routes, and mildly toxic to humans by ingestion and inhalation.^f

5.1.3 Health Effects

Trichloroethylene is a suspected carcinogen with experimental carcinogenic, tumorigenic, and teratogenic data. Human systemic effects by ingestion and inhalation are: eye effects, somnolence, hallucinations or distorted perceptions, gastrointestinal changes and jaundice. Inhalation of high concentrations causes narcosis and anesthesia. Prolonged inhalation of moderate concentrations causes headache and drowsiness. Fatalities following severe, acute exposure have been attributed to ventricular fibrillation resulting in cardiac failure.

5.1.4 Standards/Regulations

	Value	Reference
Air:		
TLV-TWA	50 mg/m ³	ACGIH ^f
PEL	50 mg/m ³	OSHA ^f
AAL	N/A	EPA 1992°
Water:		
MCL	0.005 mg/l	EPA, 1987 ^c
MCLG	0 mg/l	EPA, 1985 ^c
WQC (Acute for aquatic organisms drinking	water)	
	$4.5E+4\mu g/l$	EPA, 1980 ^c
WQC (adjusted for drinking water only)	2.7E+0 μg/l	EPA, 1980 ^c
WQC (chronic/for aquatic organism)	3.6E+2 μg/l	EPA, 1980 ^c
AAL	N/A ^c	
Drinking Water Health Advisory:		
One Day (10 kg)	N/A ^c	
Ten Day (10 kg)	N/A ^c	
Long Term (10 kg)	N/A ^c	
Longer Term (70 kg)	N/A ^c	
Lifetime (70 kg)	N/A ^c	
Potency Factor:		

Oral N/A^c

Inhalation N/A^c

RfDs:

Oral N/A EPA, 1992°

Inhalation N/A EPA, 1992^c

RfDc:

Oral 6.0E-3(mg/kg/day) EPA, 1992°

Inhalation N/A EPA, 1992^c

N/A = Information not Available

Note: $4.5E+4 = 4.5x10^4$

5.2 Summary of Toxicological Effects for Bis(2-ethylhexyl)phthalate

5.2.1 Physical and Chemical Properties of Bis(2-ethylhexyl)phthalate

A summary of the physical and chemical properties of Bis(2-ethylhexyl)phthalate follows:

Molecular weight: 390.62 g/mole^f

Boiling Point: $164.7 \,^{\circ} \,^{\circ} \,^{\circ}$

Solubility in water: Insoluble^d

Flash point, closed cup: 218 ° C^d

Vapor pressure: 1.32 mm Hg at 200 ° C^d

Octanol/water partition coefficient (Log K_{ow}) N/A

Organic carbon partition coefficient (K_{oc}): N/A

Appearance: Light-Colored^d

Melting point: -50 ° C^h

Upper explosive limit in air: N/A

Lower explosive limit in air: 0.3 %¹

Specific gravity: 0.9861^d

Heat of vaporization:

N/A

Half-life in air:

N/A

Half-life in surface water:

N/A

Fish bioconcentration factor (BCF):

N/A

Reference Dose (RfD):

2.00E-02(mg/kg-d)

Slope Factor (Sfo):

1.40E-02 1/(mg/kg-d)

a From: Casarett and Doull's Toxicology, 1991.

b From: The Merck Index, 1989.

c From: IRIS Electronic Media, 1995.

d From: Hawley's Condensed Chemical Dict., 1993.

e From: Dr. Ludwig Table-Properties of Contaminants..., 1990.

f From: Sax's Dangerous Properties of Industrial Materials, 1992.

g From: CRC Handbook of Chemistry and Physics, 1981.

h From: Lange's Handbook of Chemistry, 1992.

i From: NIOSH Pocket Guide To Chemical Hazards, 1990.

N/A = Information Not Available

5.2.2 Acute Toxicity

Bis (2-ethyl hexyl) phthalate (DEHP) is known to be ubiquitously distributed in the environment. They have been found complexed with the fulvic acid components of humic substances in soil and in both marine and estuarine waters. In general, concentrations of DEHP in fresh water lie in the range of 1 to 10 μg/ liter. Concentrations of DEHP in surface water has ranged from 4.9 to 130 mg/liter. DEHP, in general, has low acute toxicity. The intraperitoneal LD50 dose in mice ranges from 1.5 to 14.2 g/kg (Rubin and Jaeger, 1973). Ninety-day and two-year feeding studies of DEHP in rats and one-year feeding studies in guinea pigs and dogs indicated a low order of chronic toxicity. ^a

5.2.3 Health Effects

Dietary levels of 0, 0.01, 0.1, and 0.3% Di (2-ethyl hexyl) phthalate (DEHP), greater than 99% pure, were administered to male and female CD-1 mice that were examined for adverse fertility and reproductive effects using a continuous breeding protocol. DEHP was a reproductive toxicant in both sexes significantly decreasing fertility and the proportion of pups born alive per litter at the 0.3% level, and inducing damage to the seminiferous tubules. DEHP has been observed to be both fetotoxic and teratogenic (Singhe, 1972; Shiot and Nishimura, 1982). Orally administered DEHP produced significant dose-related increases in liver tumor responses in rats and mice of both sexes. ^c

5.2.4 Standards/Regulations

J.L. Tennen an regarder	Value	Reference
Air:		
TLV-TWA	5 mg/m^3	ACGIH ^f
PEL	5 mg/m^3	OSHA ^f
AAL	N/A	EPA 1992 ^c
Water:		
MCL	0.004 mg/L	EPA, 1990 ^c
MCLG	0 mg/L	EPA, 1990 ^c
WQC (Acute for aquatic organisms drinking	ng water)	
	4.0E+2μg/l	EPA, 1980°
WQC (chronic/for aquatic organism)	3.6E+2 μg/l	EPA, 1980 ^c
WQC (adjusted for drinking water only)	1.5E+4 μg/l	EPA, 1980°
AAL	N/A ^c	
Drinking Water Health Advisory:		
One Day (10 kg)	N/A ^c	
Ten Day (10 kg)	N/A ^c	
Long Term (10 kg)	N/A ^c	
Longer Term (70 kg)	N/A°	

Lifetime (70 kg) N/A^c

Potency Factor:

Oral 0.015 mg/kg/day EPA, 1989^c

Inhalation N/A^c

RfDs:

Oral 2.0E-2(mg/kg-d) Carpenter.etal1953

Inhalation N/A EPA, 1986^c

RfDc:

Oral N/A^c

Inhalation N/A^c

N/A = Information not Available

Note: $4.5E+4 = 4.5x10^4$

5.3 Summary of Toxicological Effects for Aluminum

5.3.1 Physical and Chemical Properties of Aluminum

A summary of the physical and chemical properties of Aluminum follows:

Atomic weight: 26.98 g/mole^f

Boiling point: 2450 °C^f

Solubility: Insoluble metal^f

Flash point: N/A

Vapor pressure: 1 mm Hg at 1284 °C^f

Octanol/water partition coefficient (Log K_{ow}): N/A

Organic carbon partition coefficient (K_{oc}): N/A

Appearance: Silvery Ductile Metal^f

Melting point: 660 °C^f

Upper explosive limit in air: N/A

Lower explosive limit in air: N/A

Specific gravity: 2.702^f

Heat of vaporization: N/A

Half-life in air(Al-28): 2.31 minutes^g

Half-life in water: N/A

Fish bioconcentration factor (BCF): N/A

Reference Dose (RfD): 1.00E+00 mg/kg-d

a From: Casarett and Doull's Toxicology, 1991.

b From: The Merck Index, 1989.

c From: IRIS Electronic Media, 1995.

d From: Hawley's Condensed Chemical Dict., 1993.

e From: Dr. Ludwig Table-Properties of Contaminants..., 1990.

f From: Sax's Dangerous Properties of Industrial Materials, 1992.

g From: CRC handbook of Chemistry and Physics, 1981.

N/A = Information Not Available

5.3.2 Toxicity

In certain aluminum-sensitive species such as cats and rabbits, increasing aluminum intrathecal infusion so that brain concentration is greater than 4 ug/g induces a characteristic clinical and pathological response. Initially, animals show subtle behavioral changes including learning and memory deficits and poor motor function. These changes progress to tremor, incoordination, weakness, and ataxia. This is followed by focal seizures and death within three or four weeks of initial exposure. Inhalation of finely divided powder has been reported to cause pulmonary fibrosis.^a

5.3.3 Health Effects

Retention of aluminum within bone and lung tissue occurs with intakes of greater than 1000 mg per day. Aluminum decreases absorption of fluoride, calcium, iron

compounds, and possibly cholesterol in the gastrointestinal tract. The binding of phosphorus in the intestinal tract can lead to phosphate depletion and osteomalacia. Aluminum may alter gastrointestinal tract motility by inhibition of acetylcholine-induced contractions. The most prominent early pathological change, associated with excessive aluminum absorption, is an accumulation of neurofibrillary tangles (NFTs) in cell body, proximal axons, and dendrites of neurons of many brain regions. This is associated with loss of synapses and atrophy of the dendritic tree. There is marked reduction in numbers of neurotubules and rate of cytoplasmic transport with impairment of intracellular transport. Aluminum also interacts with neuronal chromatin or DNA and is associated with a decreased rate of DNA synthesis. RNA polymerase activity is also reduced.^a

5.3.4 Standards/Regulations

	Value	Reference
Air:		
TLV-TWA	1,900 mg/m ³	ACGIH, 1989
PEL	1,900 mg/m ³	OSHA, 1989
AAL	0.31 mg/m^3	DOHS, 1988
Water:		
MCL	200 mg/l	EPA, 1989a
MCL	200 mg/l	DOHS, 1988
MCLG	200 mg/l	EPA, 1989a
WQC (for aquatic organisms drinking water)	1.84E-04 mg/l	EPA, 1989a
WQC (adjusted for drinking water only)	1.03E+06 mg/l	EPA, 1989a
AAL	20 mg/l	DOHS, 1985
Drinking Water Health Advisory:		
One Day (10 kg)	140,000 mg/l	EPA, 1986a
Ten Day (10 kg)	35,000 mg/l	EPA, 1986a
Longer Term (10 kg)	35,000 mg/l	EPA, 1986a

Longer Term (70 kg)	125,000 mg/l	EPA, 1986a
Lifetime (70 kg)	1,000 mg/l	EPA, 1986a
Potency Factor:		
Oral	ND	EPA, 1989a
Inhalation	ND	EPA, 1989a
RfDs:		
Oral	9.00E-01 mg/kg/day	EPA, 1989a
Inhalation	3.00E+00 mg/kg/day	EPA, 1989a
RfDc:		
Oral	9.00E-02 mg/kg/day	EPA, 1989a
Inhalation	3.00E-01 mg/kg/day	EPA, 1989a
ND = Not Determined		

Note: $9.00E-01 = 9 \times 10$

5.4 Summary of Toxicological Effects for Chromium

5.4.1 Physical and Chemical Properties of Chromium

Following is a summary of the physical and chemical properties of Chromium.

Atomic weight:	52.00 g/mole ^f
Boiling point at 1 atm:	2200 °C ^d
Solubility:	Insoluble Metal ^d
Flash point, closed cup:	N/A
Vapor pressure:	1 mm Hg at 1610 °C ^g
Octanol/water partition coefficient (Log K _{ow}):	N/A
Organic carbon partition coefficient (K _{oc}):	N/A
Upper explosive limit in air:	N/A
Lower explosive limit in air:	N/A

Appearance: Semi-Gray, hard, brittle^d
Melting point: 1900 °C^d
Specific gravity: 7.1d
Heat of vaporization: N/A
Half life in air(Cr-51): 26.5 days^g
Half life in surface water: N/A
Fish bioconcentration factor (BCF): N/A

5.00E-03 mg/kg-d

a From: Casarett and Doull's Toxicology, 1991.

b From: The Merck Index, 1989.

Reference Dose (RfD):

c From: IRIS Electronic Media, 1995.

d From: Hawley's Condensed Chemical Dict., 1993.

e From: Dr. Ludwig Table-Properties of Contaminants..., 1990.

f From: Sax's Dangerous Properties of Industrial Materials, 1992.

g From: CRC handbook of Chemistry and Physics, 1981.

N/A = Information Not Available

5.4.2 Acute Toxicity

Chromium is poisonous to humans when ingested, producing gastrointestinal effects.^c MacKenzie, R.D.,R.U. Byerrum, C.F. Decker, C.A. Hoppert and R.F. Langham. 1958. Chronic toxicity studies. II. Hexavalent and trivalent chromium administered in drinking water to rats. Am. Med. Assoc. Arch. Ind. Health. 18: 232-234 The authors stated that "apparently, tissues can accumulate considerable quantities of chromium before pathological changes result." ^c

No-effect levels have been observed in dogs and humans (dose group) given up to 11.2 ppm chromium(VI) (as K2CrO4) in drinking water for 4 years. The calculated doses were 0.012-0.30 mg/kg of chromium(VI). In humans, no adverse health effects were detected (by physical examination)in a family of four persons

who drank for 3 years from a private well containing chromium(VI) at approximately 1 mg/L (0.03 mg/kg/day for a 70-kg human).c

5.4.3 Health Effects

A large number of chromium compounds have been assayed during in vitro genetic toxicology assays. In general, hexavalent chromium is mutagenic in bacterial assays whereas trivalent chromium is not (Lofroth, 1978; Petrellie and Flora, 1977, 1978). Likewise Cr VI but not Cr III was mutagenic in yeasts (Bonatti et al., 1976) and in V79 cells (Newbold et al., 1979). Chromium III and VI compounds decrease the fidelity of DNA synthesis in vitro (Loeb et al.,1977), while Cr VI compounds inhibit replicative DNA synthesis in mammalian cells (Levis et al., 1978) and produce unscheduled DNA synthesis, presumably repair synthesis, as a consequence of DNA damage (Raffetto, 19 Chromate has been shown to transform both primary cells and cell lines (Fradkin et al., 1975; Tsuda and Kato, 1977; Casto et al., 1979). Chromosomal effects produced by treatment with chromium compounds have been reported by a number of authors; for example, both Cr VI and Cr III salts were clastogenic for cultured human leukocytes (Nakamuro et al., 1978).^c Results of occupational epidemiologic studies of chromium-exposed workers are consistent across investigators and Dose-response relationships have been established for study populations. chromium exposure and lung cancer. Chromium-exposed workers are exposed to both chromium III and chromium VI compounds. Because only chromium VI has been found to be carcinogenic in animal studies, however, it was concluded that only chromium VI should be classified as a human carcinogen.c

5.4.4 Standards/Regulations

9	¥7.3	D - C
	Value	Reference
Air:		
TLV-TWA	270 mg/m^3	ACGIH, 1988
PEL	270 mg/m ³	OSHA, 1989
AAL	0.007 mg/m^3	DOHS, 1988
Water:		
MCL	5 mg/l	EPA, 1989a
MCL	5 mg/l	DOHS, 1989a
MCLG	Zero	EPA, 1989a
WQC (for aquatic organisms drinking water)	2.7 mg/l	EPA, 1989a
WQC (adjusted for drinking water only)	2.8 mg/l	EPA, 1986
AAL	7 mg/l	DOHS, 1988
Drinking Water Health Advisory:		
One Day (10 kg)	N/A	EPA, 1987c
Ten Day (10 kg)	N/A	EPA, 1987c
Longer Term (10 kg)	N/A	EPA, 1987c
Lifetime (70 kg)	2.8 mg/l	EPA, 1987c
Potency Factor:		
Oral	1.1E-02(mg/kg/day) ⁻¹	EPA, 1989a
Inhalation	1.3E-02(mg/kg/day) ⁻¹	EPA, 1989a
RfDs:		
Oral	N/A	EPA, 1989a.b
Inhalation	N/A	EPA, 1989a b
RfDc:		
Oral	N/A	EPA, 1989a.b
Inhalation	N/A	EPA, 1989a.b

N/A = Information Not Available.

Note: $1.1E-02 = 1.1 \times 10-2$

5.5 Summary of Toxicological Effects for Manganese

5.5.1 Physical and Chemical Properties of Manganese

Following is a summary of the physical and chemical properties of Manganese:

Molecular weight: 54.94 g/mole^f

Boiling point at 1 atm: 1900 °C^f

Solubility: Insoluble Metal^f

Flash point, closed cup: N/A

Vapor pressure: 1 mm Hg at 1292 °C^g

Octanol/water partition coefficient (Log K_{ow}): N/A

Organic carbon partition coefficient (K_{oc}): N/A

Upper explosive limit in air: N/A

Lower explosive limit in air: N/A

Appearance: Reddish-Grey/Silvery, brittle^f

Melting point: 1260 °C^f

Specific gravity: 7.20^f

Heat of vaporization: N/A

Half life in air(Mn-54): 303 days⁸

Half life in surface water: N/A

Fish bioconcentration factor (BCF): N/A

Reference Dose (RfD): 5.00E-03 mg/kg-d

a From: Casarett and Doull's Toxicology, 1991.

b From: The Merck Index, 1989.

c From: IRIS Electronic Media, 1995.

d From: Hawley's Condensed Chemical Dict., 1993.

e From: Dr. Ludwig Table-Properties of Contaminants..., 1990.

f From: Sax's Dangerous Properties of Industrial Materials, 1992.

g From: CRC handbook of Chemistry and Physics. 1981.

N/A = Information Not Available

5.5.2 Acute Toxicity

*Conversion Factors and Assumptions: The arithmetic mean of the range of manganese concentrations for the NOAEL and LOAEL are 167 ug/L and 1950 ug/L, respectively. Assuming a water consumption of 2 L/ 0.06 mg/kg-day, respectively. The water RfD assumes a separate dietary intake of manganese, as this essential element is found in varying amounts in all diets. The NOAEL of 10 mg/day (0.14 mg/kg-day for 70 kg adult) for chronic human consumption of manganese in the diet is based on a composite of data from all three references. WHO (1973) reported no adverse effects in humans consuming supplements of 8-9 mg Mn/day (0.11-0.13 mg/kg-day). Schroeder et al. (1966) reported a chronic human NOAEL of 11.5 mg Mn/day (0.16 mg/kg-day).

It was suggested by Dieter et al. (1992) that "if there were a toxicological limit to manganese according to the principles of preventive health care, then it would have to be set at 0.2 mg/L of manganese for infants as a group at risk."^c

Many studies have reported similar findings with regard to the normal dietary intake of manganese by humans. These data are considered to be superior to any data obtained from animal toxicity studies, especially as the physiologic requirements for manganese vary quite a bit among different species, with man requiring less than rodents (Schroeder et al., 1966). There is no one study used to derive the dietary RfD for manganese. While several studies have determined average levels of manganese in various diets, no quantitative information is available to indicate toxic levels of manganese in the diet of humans. Because of the homeostatic control humans maintain over manganese, it is generally not

considered to be very toxic when ingested. Confidence in the data base is medium and confidence in the dietary RfD for manganese is also medium.^c

5.5.3 Health Effects

DiPaolo (1964) subcutaneously or intraperitoneally injected DBA/1 mice with 0.1 mL of an aqueous of solution 1% manganese chloride twice weekly for 6 months. A larger percentage of the mice exposed subcutaneously (24/36; 67%) and intraperitoneally (16/39; 41%) to manganese developed lymphosarcomas compared with controls injected with water (16/66; 24%). In addition, tumors appeared earlier in the exposed groups than in the control groups. The incidence of tumors other than lymphosarcomas (i.e., mammary adenocarcinomas, leukemias, injection site tumors) did not differ significantly between the exposed groups and controls. A thorough evaluation of the results of this study was not possible because the results were published in abstract form.^c

Stoner et al. (1976) tested manganous sulfate in a mouse lung adenoma screening bioassay. Groups of strain A/Strong mice (10/sex), 6-8 weeks old, were exposed by intraperitoneal injection to 0, 6, 15 or 30 mg/kg manganous sulfate 3 times/week for 7 weeks (a total of 21 injections). The animals were observed for an additional 22 weeks after the dosing period, before sacrifice at 30 weeks. Lung tumors were observed in 12/20, and 7/20 animals in the high, medium, and low dosage groups, respectively. The percentage of mice with tumors was elevated, but not significantly, at the highest dose level (Fisher Exact test) compared with that observed in the vehicle controls. In addition, there was an apparent increase in the average number of pulmonary adenomas per mouse both at the mid and high doses, as compared with the vehicle controls (10 mice/sex), but the increase was significant only at the high dose (Student's t-test, p<0.05).^c

5.5.4 Standards/Regulations

g	Value	Reference
Air:		
TLV-TWA	270 mg/m ³	ACGIH, 1988
PEL '	270 mg/m ³	OSHA, 1989
AAL	0.007 mg/m^3	DOHS, 1988
Water:		
MCL	5 mg/l	EPA, 1989a
MCL	5 mg/l	DOHS, 1989a
MCLG	Zero	EPA, 1989a
WQC (for aquatic organisms drinking water)	2.7 mg/l	EPA, 1989a
WQC (adjusted for drinking water only)	2.8 mg/l	EPA, 1986
AAL	7 mg/l	DOHS, 1988
Drinking Water Health Advisory:		
One Day (10 kg)	N/A	EPA, 1987c
Ten Day (10 kg)	N/A	EPA, 1987c
Longer Term (10 kg)	N/A	EPA, 1987c
Lifetime (70 kg)	2.8 mg/l	EPA, 1987c
Potency Factor:		
Oral	1.IE-02(mg/kg/day) ⁻¹	EPA, 1989a
Inhalation	1.3E-02(mg/kg/day) ⁻¹	EPA, 1989a
RfDs:		
Oral	N/A	EPA, 1989a.b
Inhalation	N/A	EPA, 1989a b
RfDc:		
Oral	N/A	EPA, 1989a.b
Inhalation	N/A	EPA, 1989a.b
N/A = Information Not Available.		
Note: $1.1E-02 = 1.1 \times 10-2$		

5.6 Summary of Toxicological Effects for Vanadium

5.6.1 Physical and Chemical Properties of Vanadium

Following is a summary of the physical and chemical properties of Vanadium.

Molecular weight:

50.9415 g/mole^b

Boiling point at 1 atm:

3000 °Cf

Solubility:

Insoluble Metal^d

Flash point, closed cup:

N/A

Vapor pressure:

1 mm Hg at 2290 °C^g

Octanol/water partition coefficient (Log K_{ow}):

N/A

Organic carbon partition coefficient (K_{oc}):

N/A

Upper explosive limit in air:

N/A

Lower explosive limit in air:

N/A

Appearance:

Silvery-White, Ductile solid

Melting point:

1917 °C^f

Specific gravity:

6.11^f

Heat of vaporization:

N/A

Half life in air(V-49):

330 days^g

Half life in surface water:

N/A

Fish bioconcentration factor (BCF):

N/A

Reference Dose(RfD):

7.00E-03 mg/kg-d

a From: Casarett and Doull's Toxicology, 1991.

b From: The Merck Index, 1989.

c From: IRIS Electronic Media, 1995.

d From: Hawley's Condensed Chemical Dict., 1993.

e From: Dr. Ludwig Table-Properties of Contaminants..., 1990.

f From: Sax's Dangerous Properties of Industrial Materials, 1992.

g From: CRC handbook of Chemistry and Physics, 1981.

N/A = Information Not Available

5.6.2 Acute Toxicity

The toxic action of vanadium is largely confined to the respiratory tract. Bronchitis and bronchopneumonia are more frequent in workers exposed to vanadium compounds. In industrial exposures to vanadium pentoxide dust, a greenish-black discoloration of the tongue is characteristic. Irritant activity with respect to skin and eyes has also been ascribed to industrial exposure. Gastrointestinal distress, nausea, vomiting, abdominal pain, cardiac palpitation, tremor, nervous depression, and kidney damage, too have been linked with industrial vanadium exposure.^a

5.6.3 Health Effects

Ingestion of vanadium compounds for medicinal purposes produced gastrointestinal disturbances, slight abnormalities of clinical chemistry related to renal function, and nervous system effects. Acute vanadium poisoning in animals is characterized by marked effects on the nervous system, hemorrhage, paralysis, convulsions, and respiratory depression. In addition, experimental investigations have suggested that the liver, adrenals, and bone marrow may be adversely affected by subacute exposure at high levels. ^a

5.6.4 Standards/Regulations

2.0		
	Value	Reference
Air:		
TLV-TWA	270 mg/m^3	ACGIH, 1988
PEL	270 mg/m ³	OSHA, 1989
AAL	0.007 mg/m^3	DOHS, 1988
Water:		
MCL	5 mg/l	EPA, 1989a
MCL	5 mg/l	DOHS, 1989a
MCLG	Zero	EPA, 1989a
WQC (for aquatic organisms drinking water)	2.7 mg/l	EPA, 1989a
WQC (adjusted for drinking water only)	2.8 mg/l	EPA, 1986

AAL	7 mg/l	DOHS, 1988
Drinking Water Health Advisory:		
One Day (10 kg)	N/A	EPA. 1987c
Ten Day (10 kg)	N/A	EPA, 1987c
Longer Term (10 kg)	N/A	EPA, 1987c
Lifetime (70 kg)	2.8 mg/l	EPA, 1987c
Potency Factor:		
Oral	1.1E-02(mg/kg/day) ⁻¹	EPA, 1989a
Inhalation	1.3E-02(mg/kg/day) ⁻¹	EPA, 1989a
RfDs:		
Oral	N/A	EPA, 1989a.b
Inhalation	N/A	EPA, 1989a b
RfDc:		
Oral	N/A	EPA, 1989a.b
Inhalation	N/A	EPA, 1989a.b
N/A = Information Not Available.		
Note: $1.1E-02 = 1.1 \times 10-2$		

6.0 RISK CHARACTERIZATION

The purpose of the risk characterization is to combine the results of the exposure and toxicity assessments into a quantitative estimate of risks due to potential chemical exposures at the Eastern Oil Lagoon Area. The risk estimates presented in this section are based on conservative assumptions which are intended to ensure the protection of human health and the environment. The high level of uncertainty in quantitative risk assessments require that conservative assumptions be made regarding chemical exposures and the toxicity associated with those exposures. An analysis of sources of uncertainty in this risk assessment is included in Section 7.0. This assessment is limited by the amount of data available to perform the calculations, but it does present a reasonable preliminary estimate of potential risks associated with groundwater in the area of the Eastern Oil Lagoon Area.

6.1 Selection of Exposure Points

The results of the exposure assessment in Section 3.0 indicated that the only reasonable route of exposure which could occur is via the transport of contaminants in groundwater to the Tallaboa Bay. If the contaminants were to actually be transported to the bay, the most likely exposure would be to someone who might fish regularly in the area. Contact with contaminants in the bay could then occur through dermal contact or the ingestion of contaminated fish or shellfish.

In this hypothetical scenario, a recreational fisherman could absorb contaminants through the skin while immersing his hands and forearms in the bay water. The bay water is not classified as suitable for swimming, so it can be assumed that dermal contact beyond the hands and arms would not likely occur. It is also assumed in this hypothetical scenario that all the fish the recreational fisherman ever eats is caught in this area. It is conservatively assumed that the same individual is exposed to contaminants in the water for the entire amount of time that an average individual spends at all recreational activities combined, for the entire duration that a person might live in the same residence. This scenario represents the "Reasonable Maximum Exposure" (RME) which could occur

to constituents in the Eastern Oil Lagoon Area groundwater as defined in EPA guidance (EPA, 1989).

6.2 Exposure Point Concentrations

Maximum detected concentrations of each constituent, which were selected as significant contributors in the selection process described in Section 2.0, were assumed to be the concentration throughout the source area. The maximum concentration of each constituent in the source area was also assumed to be the concentration at the point of exposure in the bay. Thus, physical and chemical processes of attenuation for inorganic constituents are not considered in this evaluation. In reality, attenuation of chemical concentrations in groundwater will occur by physical, chemical and biological processes before reaching the point of exposure at a receptor.

Due to the limited number of samples taken in the area, the use of statistical methods was not appropriate to describe groundwater in the source area. Therefore the maximum detected concentration of a constituent was used to represent the source concentration. This is a conservative estimation which assumes that the maximum detected concentration is found homogeneously throughout the source area.

6.3 Intake Assumptions

Exposure point concentrations are combined with exposure parameters, which describe the potentially exposed population, to produce an estimate of the chemical intake or dose which could occur under the given assumptions. Values used to represent this hypothetical exposure scenario in the risk algorithm presented in Eqn. 1 are taken from EPA studies representing the general population.

Intake = $C \times [(SA \times PC \times ET \times EF \times ED \times CF) + (BCF \times IR \times FI \times Eff \times ED)]$ BW x AT

where:

C concentration (mg/L)

BW body weight (kg)

AT Averaging Time (days)

ET Exposure Time (hours/day)

EF Exposure Frequency (days/year)

ED Exposure Duration (years)

SA Skin Surface Area (cm²)

PC Dermal Permeability Constant (cm/hr)

CF Conversion Factor (L/cm³)

BCF Bioconcentration Factor (L/kg)

IR Fish Ingestion Rate (kg/day)

Eff Exposure Frequency (days/year)

FI Fraction Ingested (unitless)

Parameters which apply to both the dermal absorption pathway and the fish ingestion pathway in Eqn. 1 are exposure duration and body weight. A conservative exposure duration of 30 years was used to represent the length of time an individual might live in the same geographical area. This is an estimate of the national 90th percentile for the length of time individuals live in the same residence (EPA, 1989). The median length of time at a single residence is 9 years as opposed to 30. An average adult body weight of 70 kg was used as the weight over which the chemical exposure is averaged (EPA, 1989).

6.3.1 Dermal Intake Assumptions

Exposure factors which affect the amount of chemical intake by dermal absorption include exposure time (ET), exposure frequency (EF), skin surface

area (SA), and the dermal permeability constant (PC). The time of exposure (ET) and frequency of exposure (EF) while fishing was conservatively derived from the entire amount of time that average individuals spend in recreational activities (EPA, 1989). A skin surface area of 3120 cm² estimates the average skin surface area of the hands and forearms (EPA, 1989). The dermal permeability constant is a chemical specific parameter which is an estimate in cm/hr of the rate at which a specific chemical can move through skin. These values were obtained from EPA dermal risk assessment guidance (EPA, 1992).

6.3.2 Fish Ingestion Assumptions

Exposure factors which affect the amount of chemical intake by the ingestion of fish include exposure frequency (Eff), fraction ingested (FI), the fish ingestion rate (IR), and the bioconcentration factor (BCF). The fish ingestion rate (IR) and exposure duration were taken from EPA estimates of the daily consumption of fish and shellfish averaged over an entire year. For this reason, the IR of 0.0065 kg/day appears to be a very small amount, but it is averaged over an EFf of 365 days/year. The fraction ingested is taken to be 1.0 due to limited EPA guidance on this parameter. This parameter could however be adjusted to more accurately reflect the fact that individuals probably do not get all their fish from a single location. The fraction of fish ingested which originated from this location would undoubtedly be less than 1.0. The BCF is a chemical specific measure of the chemical's potential to bioaccumulate in fish tissues. These values were obtained from EPA's Superfund Public Health Evaluation Manual (EPA, 1986).

6.4 Noncarcinogenic Health Risks

Toxic effects due to chemical exposures are divided into the categories of cancer toxicity and noncancer toxicity. Toxic effects other than cancer are evaluated by taking the ratio of the estimated chemical intake (produced by the previously described exposure assumptions) over an experimentally derived reference dose (RfD).

Eqn. 2

HI = Intake / RfDo

where:

HI = Hazard Index (a unitless ratio)

Intake = Chemical Intake (mg/(kg*d))

RfDo = Oral Reference Dose (mg/(kg*d))

The RfD is an estimate of a daily exposure level that is likely to be without an appreciable risk of deleterious effects during a lifetime. It is, in essence, a dose below which toxic effects are not likely to occur. RfDs for this assessment were taken from EPA published values in the Integrated Risk Information System (IRIS) or the Health Effects Assessment Summary Tables (EPA, 1995). If the estimated chemical intake under certain exposure conditions is greater than the RfD, the resulting ratio is greater than one. This ratio is referred to as the Hazard Index (HI). A chemical concentration which results in an HI of less than one is therefore not likely to result in any noncancer toxicity.

The sum of the individual hazard indices can then be summed to estimate the hazard due to simultaneous exposure to multiple substances. Summation of the toxic effects of multiple substances is an oversimplification of reality since different chemicals may effect different target organs, and multiple substance effects on a single organ are not necessarily additive. Therefore, a sum HI of greater than one does not necessarily indicate toxic effects will occur, but a sum HI of less than one indicates there is strong evidence that toxic effects are unlikely.

Hazard Indices were calculated for each constituent in the Eastern Oil Lagoon Area groundwater which were selected for consideration by the process described in Section 2.0. This process ensures that the risk assessment focuses on the most significant

constituents based on concentration and toxicity. The results of the Eastern Oil Lagoon Area non cancer HI calculations are presented in **Table 6-1**. The results show that the HI of each individual constituent is less than one and the cumulative HI of all the constituents combined is also less than one.

The two volatile constituents included in the risk assessment (trichloroethylene and bis 2-ethylhexyl phthalate) were both evaluated by the dermal absorption pathway for both carcinogenic and noncarcinogenic effects. The noncancer HI for these constituents are several orders of magnitude lower than the acceptable HI ratio of 1.0.

Because inorganic metals do not generally absorb through the skin, the only remaining pathway for these constituents is through bioaccumulation in fish and subsequent human ingestion. Of the four metals being evaluated, only chromium has EPA published data for bioaccumulation in the form of a BCF as required in Eqn. 1 (EPA, 1986). The resulting chromium HI of 0.129 is well below the 1.0 criteria for an acceptable HI.

The combined HI of 0.132 indicates that, under these exposure assumptions, there is strong evidence that the concentrations of chemicals found in groundwater in the Eastern Oil Lagoon Area are unlikely to cause any adverse noncancer toxic effects.

6.5 Carcinogenic Health Risks

Constituents which are classified by EPA as carcinogens are evaluated differently than the noncarcinogenic substances described in Section 6.4. Potential risks due to the carcinogenic effects of chemicals are described by statistical probabilities referred to as cancer risk. Cancer risks are calculated by multiplying the estimated intake described in section 6.3 by a chemical specific, experimentally derived cancer potency slope factor (SFo).

Eqn. 3

Risk = Intake x Sfo

where:

Risk = unitless probability of an individual developing cancer

Intake = chemical intake (mg/(kg*d))

SFo = oral cancer potency slope factor $(mg/(kg*d))^{-1}$

The SFo is a plausible upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen. EPA has established that a range of 1×10^{-4} to 1×10^{-6} is the range of risk probabilities which are considered reasonable. In other words one chance in a million (1×10^{-6}) of an individual developing a cancer due to a chemical exposure is insignificant in comparison to other risks which are associated with everyday life such as heart disease, automobile accidents, or even being struck by lightning (which is estimated to be approximately a 1×10^{-4} risk).

Cancer risk estimates were calculated for each constituent in the Eastern Oil Lagoon Area groundwater which was selected for consideration by the process described in Section 2.0. This process ensures that the risk assessment focuses on the most significant constituents based on concentration and toxicity.

Table 6-1 along with the noncancer HIs. The cancer risk estimates for both trichloroethylene and Bis(2-ethylhexyl) phthalate were in the 10⁻⁸ range. These values are well below the range of acceptable risks identified by EPA to be 1 x 10⁻⁴ to 1 x 10⁻⁶.

The cumulative risk estimate of 1.33×10^{-7} is an upper-bound estimate of risk for trichloroethylene and Bis(2-ethylhexyl)phthalate exposure. Thus, there is approximately

a one in ten million chance that an individual could develop a cancer from exposure to constituents found in the Eastern Oil Lagoon groundwater area based on the described assumptions. EPA guidance states that this means we can be "reasonably confident that the *true risk* will not exceed the risk estimate derived through use of this model and is likely to be less than that predicted".

Table 6-1. Baseline Risk and Hazard Index Calculations

Dermal Contact with Surface Water and Ingestion of Fish

Chemical	Max Conc. (mg/L)	SFo 1/(mg/kg-d)	(mc)	BCF (Ľ/kg)	THE STATE OF THE S	∝Cancer ∠≛Risk	Hazard Index
Trichloroethylene	0.014	1.10E-02	6.00E-03	10.6	0.016	7.99E-08	2.82E-03
Bis(2-ethylhexyl) phthalate	0.019	1.40E-02	2.00E-02	NA	0.033	5.31E-08	4.42E-04
Aluminum	200.5	NA	1.00E+00	NA	NA	NA	0.00E+00
Chromium	0.434	NA	5.00E-03	16	NA	NA	1.29E-01
Manganese	7.83	NA	5.00E-03	NA	NA	NA	0.00E+0ე
Vanadium	1.5	NA	7.00E-03	NA	NA	NA	0.00E+ು ೨
					Totals	1.33E-07	1.32E-01

7.0 SOURCES OF UNCERTAINTY AND ERROR

The U.S. Environmental Protection Agency (EPA) has issued guidelines for risk assessment to promote technical quality and consistency in the risk assessment process (51 CFR 33992-34054, September 24, 1986). In addition to providing technical information and policy guidance, the guidelines also stress that risk assessments should include a discussion of the strengths and weaknesses of each assessment by describing uncertainties, assumptions, and limitations, as well as the scientific basis and rationale for each assessment.

Risk assessments inherently include uncertainties due to the nature of the science. In attempting to model real world situations based on limited knowledge, certain assumptions must made in the process. It is EPA's policy, based on its mission to protect human health and the environment, to err on the side of being overly protective when uncertainties are involved in the process. Therefore uncertainties in each step of the environmental risk assessment process are dealt with by conservatism. When conservatism is compounded from one step of the process to the next, the end result is unrealistic, often inflated estimates of risk. The purpose of the uncertainty analysis is to document these sources of uncertainty so that one can be cognizant of these issues when looking at calculated estimates of risk.

There are three broad areas where uncertainties may be found in the risk assessment process:

- 1) Sample Collection and Analysis
- 2) Chemical Toxicity Data (derived from animal or epidemiological studies)
- 3) Exposure and Intake Models

For each of these three areas, a number of factors may increase or decrease the confidence in the accuracy of the risk assessment. These factors, as they may apply to this assessment, are as follows:

Sample Collection and Analysis

- Sample collection methods
- Analytical methods, detection limits, quality control/quality assurance procedures
- Rationale for placement of samples
- Accurate characterization of area geology and hydrology
- Representativeness and completeness of data
- Adequacy of data to describe site conditions

Chemical Toxicity Data (derived from animal and epidemiological studies)

- Choice of species, strain, age, and sex of animals
- The number of animals or people in the study
- Similarity in the routes of exposure between the tested species and route of interest in humans
- Purity of test compound
- Decay of test compound and vehicle contribution
- Selection of dose levels and use of control groups
- Distribution of animals among doses
- Similarity between test animals and humans in metabolism and pharmacokinetics
- Statistical noise; statistical methods used to analyze data
- Proper histopathological examination of animals
- Proper animal husbandry and dietary considerations
- Experimental surroundings
- Consideration of concurrent exposures in epidemiological studies
- Exposure measurements concurrent to the period being evaluated in epidemiological studies
- Selection of proper endpoint in animal or epidemiological studies
- Synergism/antagonism

- Animal to human extrapolation: high dose to low dose, choice of dose/response model, confidence intervals
- Use of most sensitive, inbred animals versus average, heterogeneous animals.

Exposure and Intake Models

- Groundwater and surface water usage
- Magnitude and duration of exposure to contaminated media
- Characteristics of the potentially exposed population

Uncertainties in this groundwater risk evaluation have been substantially reduced because appropriate QA/QC methodologies have been used and all field data have been validated. Conservative assumptions regarding the toxicity of the compounds, and the use of standard recommended EPA exposure parameters assure that the uncertainties in this groundwater risk evaluation are dealt with in a manner that is protective of human health and the environment.

8.0 SUMMARY AND CONCLUSIONS

This preliminary baseline groundwater risk analysis assesses the public health risks associated with chemicals detected in on-site groundwater at the CORCO Eastern Oil Lagoon Area. The chemicals of concern include:, Trichloroethylene, Bis(2-ethylhexyl) phthalate, Aluminum, Chromium, Manganese and Vanadium. Indirect ingestion of marine biota and dermal contact with the waters of Tallaboa Bay were considered in this evaluation. Potential health risks associated with indirect ingestion and dermal exposures were quantified for one current potential receptor population: offsite recreational fishermen. Potential indirect ingestion and dermal exposures to future receptor populations were not calculated separately, as future risks from indirect ingestion and dermal contact of the site chemicals are expected to be equal to or less than the risks associated with the current exposure scenario. Health risks to current and potential future receptor populations associated with indirect ingestion of marine biota and dermal contact with the waters of Tallaboa Bay, in the absence of Eastern Oil Lagoon Area groundwater remediation, were also quantified. One distinct receptor population was evaluated: individuals whose contact with contaminants in the bay could occur through dermal contact or the ingestion of contaminated fish or shellfish. Additionally, potential lifetime health risks to populations from the indirect ingestion of marine biota or dermal contact with the waters of Tallaboa Bay were estimated.

- The results of this groundwater risk evaluation indicate that both carcinogenic risks and noncarcinogenic adverse health effects associated with the ingestion of marine biota and dermal contact with the waters of Tallaboa Bay potentially impacted by Trichloroethylene, Bis(2-ethylhexyl) phthalate, Aluminum, Chromium, Manganese and Vanadium were well below EPA established "acceptable" levels.
- No "unacceptable" health risks were found from either exposure to individual site chemicals or from exposure to a mixture of these chemicals via indirect ingestion or dermal contact.

- Based on the results for the Fish ingestion and dermal contact pathways, no excess cancer risks (Cancer Risk 1.33E-07) or adverse noncarcinogenic health effects (Hazard Index 1.32E-01) result from the absence of groundwater remedial action at the CORCO Eastern Oil Lagoon Area.
- 4) Remedial action for the groundwater at the Eastern Oil Lagoon Area is not recommended.

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TABLE 1
GROUNDWATER LEVEL MEASUREMENT RESULTS

MONITOR WELL	MONITORING DATE	TOP OF CASING ELEVATION (FEET ABOVE SEA LEVEL)	DEPTH TO GROUND FROM TOP OF CASING (FEET)	ELEVATION OF GROUNDWATER (FEET ABOVE SEA LEVEL)
PD-1	9/27/1994	7.51	5.36	2.15
PD-2	9/27/1994	11.71	9.91	1.80
WL-2	9/27/1994	10.28	9.37	0.91
WL-3	9/27/1994	8.22	6.71	1.51
WL-4	9/27/1994	7.29	5.19	2.10
EL-1	9/27/1994	15.29	10.07	5.22
EL-2	9/27/1994	17.28	16.26	1.02
EL-3	9/27/1994	10.1	9.21	0.89
EL-4	9/27/1994	10.79	11.61	-0.82
PD-2	10/05/1994	11.71	9.37	2.34
WL-2	10/05/1994	10.28	9.27	1.01
WL-3	10/05/1994	8.22	6.60	1.62
WL-4	10/05/1994	7.29	5.25	2.04
EL-1	10/05/1994	15.19	9.75	5.44
EL-2	10/05/1994	17.23	15.75	1.48
EL-3	10/05/1994	9.81	8.30	1.51
EL-4	10/05/1994	10.47	10.75	-0.28

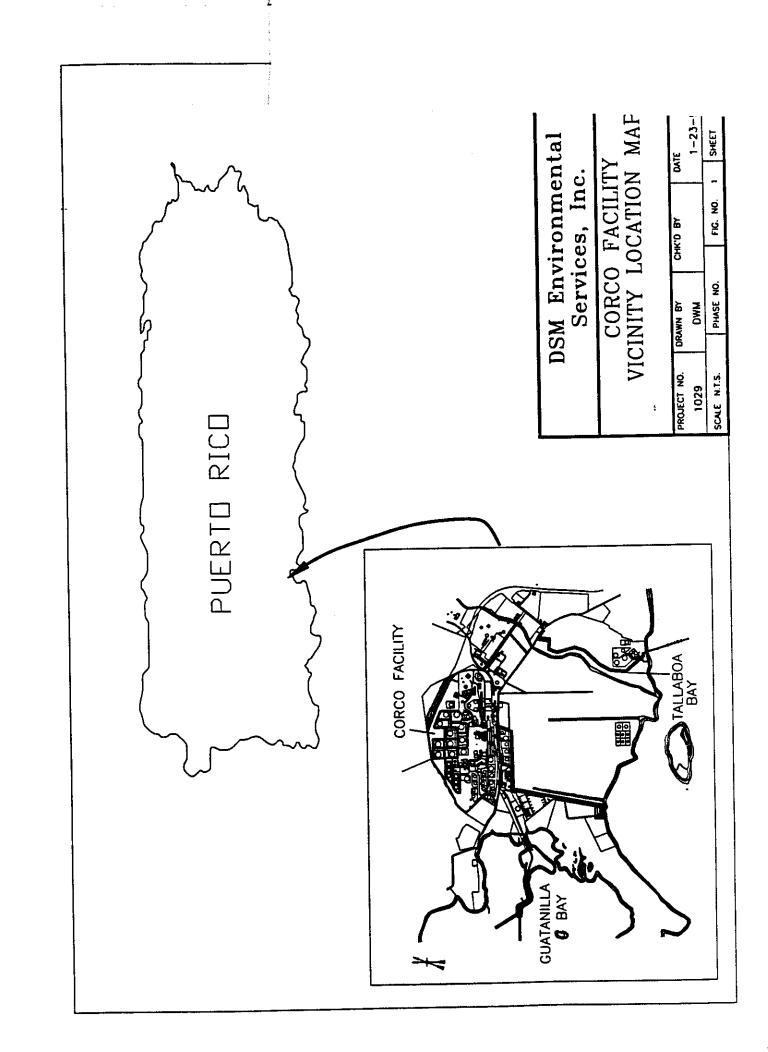
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Acetone	8	<100.0	< 100.0	< 100.0	<100.0	<100.0	130	< 20.0	< 20.0	< 20.0	<100.0
Benzene	2	<5.0	<5.0	<5.0	<5.0	<5.0	< 10.0	< 10.0	2.91	< 10.0	<5.31
2-Dichloroethane; Ethylene dichloride	0.5	<5.0	<5.0	<5.0	<5.0	<5.0	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0
cis-1.2-Dichloroethene	T	6.6	<5.0	31.8	<5.0	34.8	247	< 10.0	<10.0	<10.0	32.1
Ethylbenzene	7	<5.0	<5.0	<5.0	<5.0	<5.0	< 10.0	<10.0	<10.0	< 10.0	< 10.0
Trichlomethylene: Trichlomethene	-	10.3	<5.0	<5.0	<5.0	<5.0	14	< 10.0	<10.0	< 10.0	< 10.0
Vinyl chloride	2	< 10.0	< 10.0	13.1	<10.0	< 10.0	< 10.0	< 10.0	7.43	< 10.0	5.93
Xviene (total)	۳	<5.0	<5.0	<5.0	<5.0	<5.0	< 10.0	< 10.0	< 10.0	< 10.0	<10.0
SEMI-VOLITILES											
4-Dimethylphenol	٣	< 10.0	< 10.0	< 10.0	< 10.0	<10.0	<4.0	<4.0	<4.0	<4.0	<4.0
Phenol	†=	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 4.0	<4.0	<4.0	<4.0	<4.0
Accophenone	≘	< 10.0	< 10.0	<10.0	< 10.0	<10.0	<4.0	<4.0	<4.0	<4.0	NR
2-Methylnaphthalene	2	<10.0	< 10.0	< 10.0	< 10.0	< 10.0	< 4.0	<4.0	<4.0	<4.0	<4.0
Naphthalene	ă	< 10.0	< 10.0	<10.0	< 10.0	<10.0	<4.0	<4.0	<4.0	<4.0	<4.0
Phenanthrene	ă	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	<4.0
Diethyl phthalate	~	< 10.0	0.01 >	< 10.0	< 10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	0.2J
Di-n-octyl phthalate	æ	< 10.0	< 10.0	<10.0	< 10.0	< 10.0	<4.0	0.91	<4.0	<4.0	<4.0
Bis(2-ethylhexyi) phthalate	2	< 10.0	< 10.0	<10.0	< 10.0	< 10.0	<4.0	19	<4.0	<4.0	<4.0
Acenaphthene	200	< 10.0	< 10.0	<10.0	< 10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	<4.0
1,2-Benzanthracene	200	< 10.0	< 10.0	<10.0	< 10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	<4.0
,4-Benzofluoranthene	82	< 10.0	<10.0	<10.0	< 10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	<4.0
Benzo(a)byrene	200	< 10.0	< 10.0	<10.0	<10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	<4.0
Chrysene	200	< 10.0	< 10.0	<10.0	< 10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	<4.0
Dibenzofuran	≘	< 10.0	< 10.0	< 10.0	< 10.0	<10.0	<4.0	<4.0	<4.0	<4.0	<4.0
Dimethylnaphthlene		N/A	N/A	A/A	N/A	N/A	<4.0	<4.0	<4.0	<4.0	<4.0
2,3-Dimethylnaphthlene		N/A	N/A	N/A	N/A	N/A	<4.0	<4.0	<4.0	<4.0	<4.0
Ethyl dimethyl benzene		Y/X	N/A	N/A	W/A	V/V	<4.0	<4.0	<4.0	<4.0	<4.0
Fluoranthene	8	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	<4.0
2-Methyl phenol		A/N	A/N	N/A	Y/N	N/A	<4.0	<4.0	<4.0	<4.0	<4.0
4-Methyl phenol		N/A	N/A	N/A	V/V	N/A	<4.0	<4.0	<4.0	<4.0	<4.0
1-Methyl naphthalene		N/A	A/N	N/A	N/A	N/A	<4.0	<4.0	<4.0	<4.0	<4.0
Methyl decahydronaphthalene		N/A	N/A	N/A	N/A	N/A	<4.0	<4.0	<4.0	<4.0	<4.0
Pyrene	200	< 10.0	< 10.0	<10.0	<10.0	< 10.0	<4.0	<4.0	<4.0	<4.0	<4.0
Tetrahydrothiophene		N/A	N/A	N/A	N/A	N/A	<4.0	<4.0	<4.0	<4.0	<4.0
Tetrahydrothiophenedioxide		N/A	N/A	N/A	N/A	N/A	<4.0	<4.0	×4.0	<4.0	<4.0
Trimethylbenzene		N/A	N/A	N/A	N/A	A/A	<4.0	<4.0	×4.0	<4.0	<4.0
Trimethyolbenzoic acid		A/N	N/A	N/A	N/A	N/A	<4.0	<4.0	<4.0	<4.0	<4.0

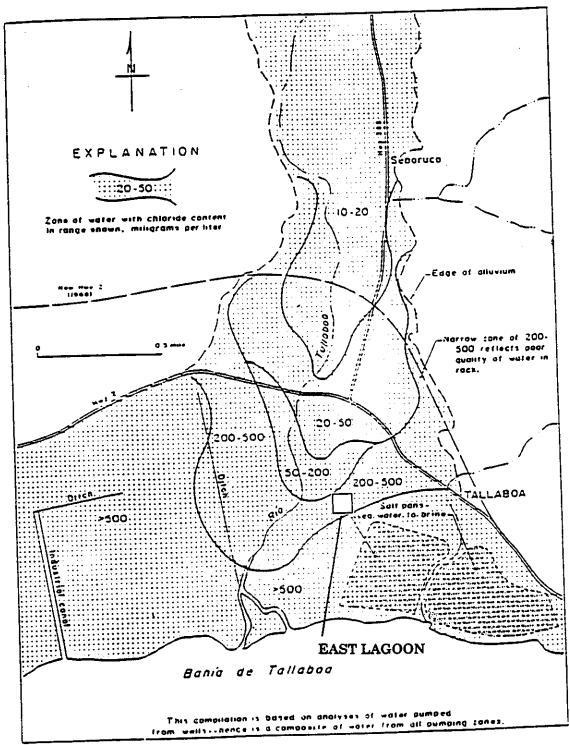
CONSTITUENTS FOL EL-1 EL-2 EL-3 EL-4 EL-5 EPA EPA EPA EL-5 EPA EPA EL-5 EPA EL-5 EPA EL-5 EPA EL-5 EPA EL-5 EPA	PQL	1-13	EL-2	E13	7	EL-5	EPA T	YAB	NAT I	V43	FI STATE BILLS
LABORATORY ID: NO.		9401140055	9401140057	9401140059	9401140061	9401140064	9401140067	é .	1200 I 100 E	2004-1048 14007-1	9401140075
WATUK		Water (ug/l)	Water (ug/l)	Water (ug/l)	Water (ug/f)	Water (ug/l)	Water (ug/I)	Water	· Vvater F (ug/l)	Water (ug/l)	Water: (ug/l)
TOTAL METALS AND CONVENTIONALS	TONA	LS									
Silver	5	92	30	20	20	20	< 10.0	< 10.0	< 10.0	< 10.0	< 10.0
Aluminum		N/A	A/N	A/X	N/A	N/A	141000	78300	200500	158000	197000
Arsenic	90,	9.3	35.4	61.8	74.9	48:3	<100.0	< 100.0	< 100.0	< 100.0	< 100.0
Barium	20	580	470	620	480	405	<2000.0	<2000.0	< 2000.0	< 2000.0	465
Beryllium	6	< 10.0	<10.0	< 10.0	<10.0	< 10.0	<5.0	<5.0	<5.0	<5.0	<5.0
Cadmin	3	< 5.0	0.9>	<6.0	0.9>	15	< 50.0	< 50.0	<50.0	< 50.0	<5.0
Calcium		N/A	N/A	N/A	N/A	N/A	183000	320000	464000	601000	483000
Cobalt	2	110	001	230	170	160	<500.0	<500.0	< \$00.0	< 500.0	174
Copper	8	004	350	069	200	480	376	<250.0	511	410	522
Chromism	70	220	220	540	390	390	189	149	434	327	378
in in its second and		A/N	N/A	A/N	A/N	V/A	208200	143400	377800	349000	348000
Mercury	2	<0.2	<0.2	<0.2	<0.2	<0.2	0.34	<0.2	0.28	0.29	0.45
Magnesium		A/N	N/A	N/A	V/A	N/A	84000	149000	154000	174000	160000
Manganese		V/N	N/A	N/A	V/N	N/A	4260	4190	7830	6840	7930
Polassium		A/N	A/X	Y/X	Y/X	A/N	< 50.0	< 50.0	< 50.0	< 50.0	18000
Sodium		N/A	N/A	V/A	Y/X	A/A	00079	133000	189000	162000	195000
Tead	\$	19.7	18.1	39.6	29.6	31.2	13	39	< 30.0	< 30.0	47
Nickel	8	130	130	300	280	230	< 400.0	<400.0	<400.0	<400.0	205
Selenium	750	<2.0	<2.0	<2.0	<2.0	<2.0	< 50.0	< 50.0	< 50.0	< 50.0	110
Ţ	8000	< 1000.0	< 1000.0	<1000.0	<1000.0	< 1000.0	N/A	N/A	N/A	N/A	A/X
Antimony	900	<100.0	< 100.0	< 100.0	< 100.0	<100.0	<600.0	< 600.0	<600.0	< 600.0	<600.0
Thalliam	9	130	350	350	350	300	<100.0	<100.0	<100.0	<100.0	<100.0
Vanadium	98	999	630	1750	1000	1220	7353	< 500.0	15003	10801	1450J
Zinc	ន	99	360	820	540	540	<400.0	<400.0	1210	1150	558
Cvanide	₽	<2.0	<2.0	<2.0	<2.0	<2.0	N/A	N/A	N/A	N/A	A/N
	,,,,,,,		0 90,	0 00-	-		*11.4	AT/A	¥/N	MILE	W1/4

Analyte positively identified; Reported value may not be accurate or precise. Not Analyzed No Result , § §

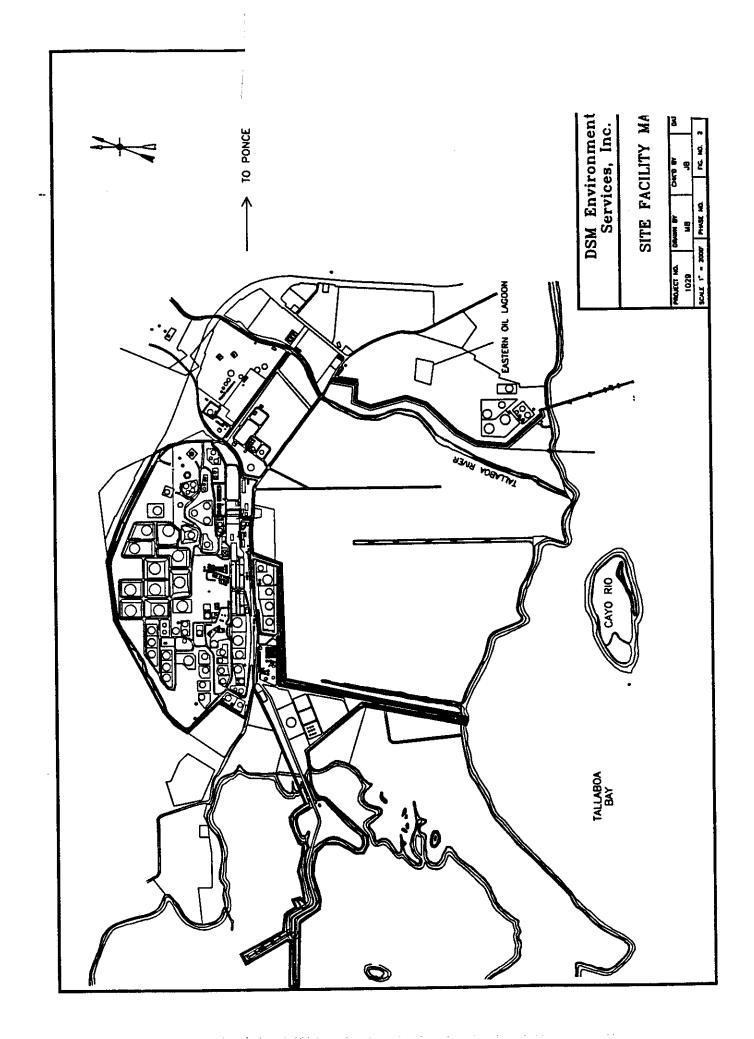
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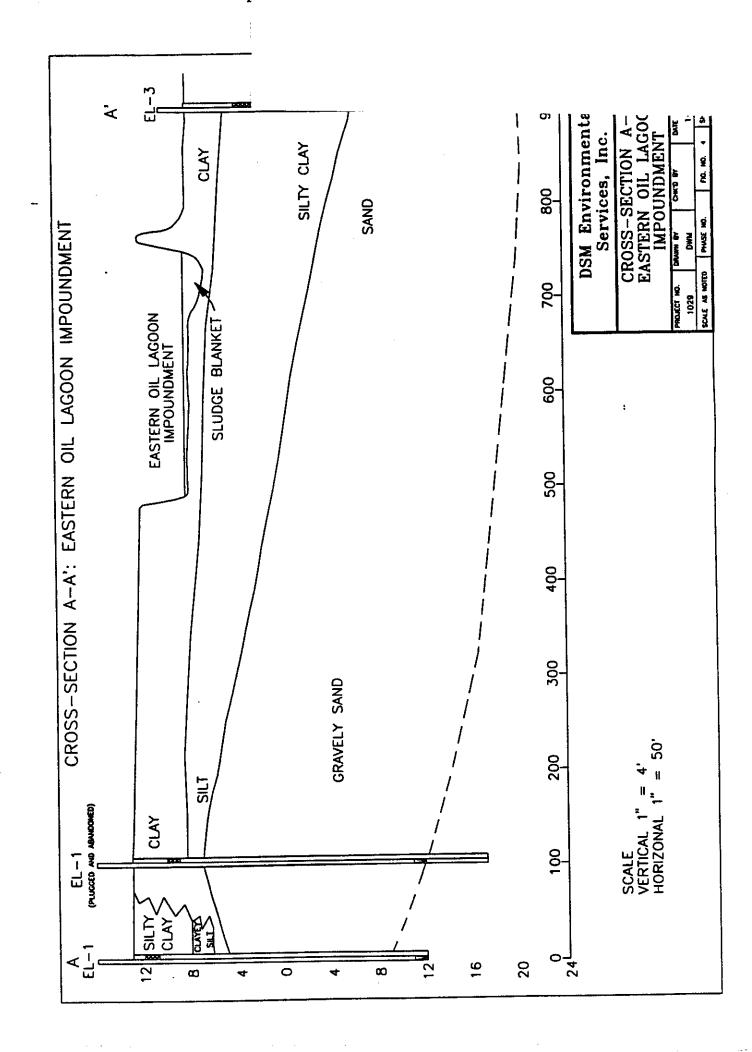


WATER RESOURCES OF THE TALLABUA VALLE L. PUERTO RICO



From Water Resources Bulletin 7, United States Geological Survey





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